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HIGH SPEED ENGINES.

IT is with considerable surprise that we have heard it said that an article of May 17th, in which we took exception to Mr. Robinson's paper on the Willans engine, was probably prompted by some personal motive. Such a report could only have been set afloat by a mind incapable of understanding the true spirit of technical journalism, for nothing could be further from the truth. Our objections to the paper were based entirely on ethical grounds. We think it would be exceedingly mischievous if an impression were to get abroad that electrical engineering were of so critical a nature that but one steam engine in the world could usefully be employed in the business. What sort of a reception would be accorded to any firm of electrical manufacturers who carried into effect with the dynamo what has been done by Messrs. Willans & Robinson with their engine? How would the Institution of Electrical Engineers deal with Mr. Crompton, for example, were he to occupy much of their time in trying to prove that good dynamos could not be made excepting on a line 27½ minutes east longitude from Greenwich. Yet the engine question has become narrowed down to almost such a contention. Mr. Robinson stated that about 100,000 horse-power of his engines have been made, yet he prefaced his paper by saying that it was to be both a description and a defence. Now, nobody has ever attacked the engine to begin with, and in face of its undoubted success, is it rational to begin a defence? We should have had nothing to say had Mr. Robinson used the word *defiance*, for then the preface would have admirably fitted the rest of the paper, which was one defiance of other engines, while as to any description being necessary, surely the day is too late for this. Let us suppose something more is to be learned on the question of balancing a rotating engine shaft. Such a subject could have been treated entirely without reference to any particular engine. As a rotating engine with crank, piston, and an oscillating rod, a Willans engine is exactly on all fours with every other piston engine, and balancing resolves itself into keeping the C.G. moving in the smallest possible orbit, either longitudinally or transversely. Absolute immobility cannot easily be obtained except by the method adopted in the De Laval turbine. Mr. Crompton, as President of the Institution took upon himself to go outside its walls to draw attention to what he termed our unfair criticism. Curiously enough, he unconsciously backed up our own arguments, for he complained that Mr. Brotherhood had not been sufficiently named in—the *discussion*. Why the discussion? Should not the paper itself have contained many such references, not alone to Mr. Brotherhood? But it named only the Belliss engine. Valuable time that might have been spent in describing "recent

developments of the single-acting engine" was given over to abuse of a double-acting engine, which hardly needed to be named under the title of the paper. The President, instead of holding an even balance—as a President should do—made a long speech of an entirely one-sided nature, and made a very serious blunder when he referred to locomotives, attacking French locomotives because they are outside connected, and claiming for the Great Northern Railway of England enclosed engines. This is erroneous. The one locomotive that has made the name of the Great Northern Railway synonymous with high speed is the 8 feet outside connected engine with exposed works, as used also on the North Western, the South Western, and half the railways of England, and when English locomotives are not outside connected, they are equally not enclosed, but fully open below to the road bed, as also is every locomotive in North America, just as much as here or in France. Then to show the spirit animating the President, it was noticed that he referred to makers and users of engines of higher piston speed, but fewer reciprocations, as the "enemy," an assumption of antagonism to a large section of the engineering trade, and to half the electrical engineers, in exceedingly bad taste. Were his ideas to become law, the future of electrical engineering would perhaps see nothing but small engines and small dynamos of 300 H.P. Is there any certainty whatever that the future central station will be made up of great numbers of small units with a multiplicity of connections when the constructive ability of electrical engineers is satisfied as to the perfect feasibility of larger units? As the size of the station, so the size of the units will be.

In his reply, the author claimed to have made the paper as general as he could, and yet he also stated he had not thought it necessary to even name the Westinghouse engine. He would have referred to the Chandler engine, but nothing had been published about it. We ask, are papers to be a digest of already published facts, instead of chronicles of developments? Evidently they are, and we disagreed with this very feature of the paper. Mr. Morcom was accused of converting the discussion into a duel between single and double-acting engines. Surely, after the attack on the Belliss engine by the author, for the paper was very directly such, was Mr. Morcom to sit quietly down and not say a word for his own engine, or point out defects in the single-acting engine? This is asking that the single-acting engine shall be swallowed whole, and denying the right of private judgment to all engineers, or of self-defence to an attacked rival. Indeed, the President's speech was simply a plea for single-acting engines, and a condemnation of everyone who ventured to have any other opinion. When the President takes the sort of stand taken by Mr. Crompton, it is hardly likely that makers of engines or boilers, of which the Chair does not approve, will expose themselves to the chance of the Chairman's final remarks. If persisted in, the Institution of Electrical Engineers will be reduced to a jelly-like mass, cast in the presidential mould of the year. Mr. Crompton was very illadvised when he set himself, in his official capacity, to lay down the law to the profession as to what motive power they must use so as to escape the stigma of incompetence. Such conduct is, to our mind, infinitely worse than the reference to his wares by a manufacturer in reading a paper. If he can get his paper accepted, why should he not extol his own goods? But we do look for an unbiassed chairman.

Moreover, we do not stand alone in this matter, as we could very quickly show. There is, and has been, for some time a strong feeling abroad to which our article did but give a voice. The feeling extends to many, who, like ourselves, are perfectly friendly to single-acting engines, and to many who are even users of them and would purchase them to-morrow if they had need of an engine; men by whom the late gifted designer of the engine particularly in question was sincerely respected. But all this does not alter the moral aspect of the case. Because high speed engines have been found so exceedingly useful in electrical engineering it does not follow they are alone available. If we were to follow the author's method of judging solely by numbers, what would be the result of comparing American electrical engineering with that of England? Our superior work and methods would not deserve mention on the same day with American work. Americans who boast so much of their weight of numbers in electrical railroads might thus ignore the Liverpool electrical line altogether. Yet it is probable that the bulk of American electrical driving engines are of the small horizontal variety of slide valve or Corliss engines, as anyone who was at the Chicago fair would perceive. Americans have laid themselves out to produce small economical engines of these types, and they are run at very fairly high speeds. English engine builders have neglected the type, and large engines have not been employed simply because the division of units has been found desirable, and electrical stations are all so very small as yet. There must be something like 800,000 or 1,000,000 horse-power in slow-running engines in the spinning branch of the cotton trade alone, so that the frantic cry for the builders of these engines to come forward and say something in their favour may well be received with a smile by the slow-speed men, who, if tackled on the question, would probably tell us that they did not have the same faith in the continuance of the infantile condition of electricity as was held by the supposed best friends of the electrical industry; that they looked forward to a demand for larger units, and could well afford to take their chance with high-speed engines of 1,000 horse-power when the time came for such powers. The publication a few days ago in a contemporary of a beam engine by a Scotch firm for a Bolton mill, is evidence of the freedom from trammels that still marks the textile engineers. These beam engines were of quite novel design, nothing like the old beam engine, but they have what was always held as a good feature in the old engines, viz., a vertical cylinder.

In conclusion, we would emphasise the matter of our criticism, though we might wish that we were gifted with more pleasant ways of putting it forward. We do but reflect a phase of thought in this matter, advocating no one make of engine, and would not be understood as advising large engines of mill type for electrical work, or of objecting to a certain degree of sub-division of units. Our criticism was directed against a doctrine that is being taught, that has no sufficient basis, and whose acceptance would have the worst effect in fixing practice down to certain hard and fast lines, from which progress would be impossible. The tone in which both the reply of the author and the closing

remarks of the President were couched, amply justifies all we had said. What is it to the Institution that, as a trader, their President bought a certain engine 19 years ago, and is it right that Mr. Raworth's remarks should, by the same voice, be pronounced unfair. Far more blame attaches to Mr. Crompton in this matter than to the manufacturers whose goods he upholds. If the various engineering societies of this country are to be used, as there appears to have been a tendency to use them of late, this should be made plain for the benefit of all. It is but a few years ago that this tendency was seen and grasped by the promoters of a certain electrical process, and advantage taken of it to have a paper read, which we know gave great offence to members, and for which it was even stated there had been a monetary consideration. All this is not to the credit of our English institutions, and we shall continue to protest against it at all times, and it is for this that we draw so clear a distinction between Mr. Willans's original papers and those that have followed. Papers ought not to be presented which tell us nothing new, which contain remarks derogatory to other manufacturers' wares, or simply excite bad feeling and acrimonious discussion, and who was there of the audience on May 9th that was not in possession of the facts of the paper, or unable to easily acquire them from published papers. An engine so old as Mr. Crompton states, viz., over 20 years, surely does not require to be explained to-day. Nor is it seemly that electrical engineers should be dragged by the car of any manufacturing Achilles: that alone of all engines it should be claimed that the particular distribution of cast-iron in a Willans engine gives a conformity with the so-named Willans law, a law no doubt of equal application to any engine, as to which our readers would do well to read the remarks of Prof. Unwin in his recent James Forrest Lecture: that any particular feature of mechanical construction is bad if it be not one employed at Thames Ditton, as to which witness the change in the attitude towards expansive working. Not long ago expansive working was a foible on which only a few Englishmen foolishly followed the Americans, who certainly did carry matters too far in the direction of expansion. But in those days they had no expansion valve at Thames Ditton. Lately, however, one has been found to suit the Willans engine. It is—may we be forgiven for stating the fact—a very slight modification of a well known Lancashire patent, still much used, but some 50 years old. That it will act admirably we think there is little doubt. Its action is equivalent to the sudden addition of lap to a slide valve, and this can be made to take place at any point in the stroke, independently of the motion of the valve, for it acts transversely to the motion of the valve. Now this little adjunct has converted Thames Ditton to expansive working. It is a trifle rough on their followers who have gone into the world breathing slaughter against this mode of working, to find the heresy now forming part of doctrine itself.

True it is somewhat modified by being worked in conjunction with throttling, and there is fair reason to suppose that this principle of compromise is good and sound, but here again the much abused so-called fountain head has been gone to for the idea. Combined throttling and expansion on somewhat similar lines was carried out in Lancashire over fifty years ago where the throttle took care of the variations instantly and the cut off valve came into action more slowly than is now the practice and brought the engine back to normal speed with normal opening of throttle. We do not find fault with the method nor its adoption at Thames Ditton. We merely point out how the much abused so-called Lancashire practice has been drawn upon, and how it has given so complete a turn to the doctrine hitherto preached as gospel. Probably the placing of some Willans engines amongst the barbarians of the North has brought someone into contact with the above valve motions and effected the conversion to expansive working which we now see.

An Electrical Speaker.

All the world reads the *Weekly Dispatch*, and hence all the world knows now that in Dr. Gully, the new speaker of the House of Commons, the political parties of this enlightened country possess not only an ornamental figure-head (for is he not "clever, handsome, and agreeable?"), but one who is endowed with great *personal electricity*. The *Weekly Dispatch* has said so, *ergo*, who shall gainsay it? We are informed that Dr. Gully himself attributes the extraordinary influence which he exerts upon everyone with whom he comes in contact, to his possession of wonderful electrical powers. People used to call it animal magnetism, but our contemporary, with up-to-date superiority, terms it electricity.

> Our readers are doubtless aware (says our contemporary, worthily endeavouring to make itself understanded of the people) that a magnet or needle has positive electricity at one end and negative electricity at the other. If the positive end of one magnet be brought near the positive end of another, they repel each other, and so do two negatives, but unlike ones attract each other. Dr. Gully's idea (in endeavouring to explain his wonderful powers) was that when persons charged with like electricity came near each other a feeling of repulsion was created, but persons of opposite electricity felt a liking for each other, and this feeling was strong in proportion to the amount of electricity with which they were charged. This was his explanation of the undoubted fact that we often experience a strong feeling of liking or aversion for people at a first interview, for which we can give no reason.

Our contemporary then reverts to an anecdote which it declares it heard the doctor himself relate. It seemed that a lady suffered from sleeplessness, so when she consulted the doctor he took her by the hand and very kindly expressed his sympathy: whereupon she immediately went into a sound sleep, which, however embarrassing to the doctor, was so refreshing to her that she begged him to repeat the experiment. Now the lady lived at a distance, so the worthy doctor determined to bridge space in the following way, since he could not hold the lady's hand every evening. He bethought him of the electrical properties of amber, and

> bought a string of amber beads, held them in his hand for some minutes, and then packed them in a box and sent them to the lady by post, directing her to take them out and hold them in her hand. She sent them back with a letter, telling him that on following his prescription she had enjoyed a good night's rest. Many times the necklace went backwards and forwards, till one day the doctor received a note to this effect: "Who has been playing tricks with those beads? On taking them in my hand to-day I went into convulsions.' The doctor immediately sent for his secretary, and asked him, "What did you do with that parcel I gave you the day before yesterday?" The man coloured, and looked uneasy, but said nothing. On being pressed, however, he acknowledged that, seized with a sudden fit of curiosity, he had opened the parcel, handled the beads, and then repacked and posted them.

What could be more circumstantial and convincing? In the face of such an authentic story, how dare we, a mere technical journal, venture to make any further comment? We may be excused, however, for hoping that the new speaker will use his wonderful powers in the House,

PAPER CABLES.

To the last few numbers of *Electric Power*, Mr. J. D. Bishop has contributed a series of articles "On the Uses of Paper as an Insulator for Electrical Conductors." Mr. Bishop says there is nothing in the least new in the application of paper ribbon or strip as an insulator for a conducting wire. It was used in the Cape of Good Hope for insulating conductors in 1859 and 1860. It is mentioned in several old hand-books as a good method of insulating wires for induction coils, and was certainly practically applied for commercial purposes by several makers of electrical apparatus, notably by the firm of Aboilard & Co., of Paris (Maison Bonis), some 20 years ago.

In very large conductors, Mr. Bishop thinks that "the employment of rubber, or any of the asphalted compounds, is, to say the least, very inadvisable, and with the so-called fibre and compound cables, impossible. The first on account of the expense, and the second on account of the hard and stiff nature of the compound when cold."

Whilst America has taken the lead of Europe in the introduction and use of paper for telephone cables, it is otherwise with electric light conductors. "In Europe, paper insulation is used with great success in cables of single, double, multiple, and concentric conductors. Comparatively so long ago as four or five years, Ferranti used paper cables in his 10,000-volt Deptford mains, with entire success. The reason may be partly found in the fact that electric light and power installations have not enjoyed the benefit of that intelligent research and fostering care which comes from centralisation of management and engineering, such as is established by the telephone companies of the United States."

Mr. Bishop devotes considerable attention to paper cables for telephone purposes. In New York he states there are 30,000 miles of conductors in cables of this kind, and in other cities proportionate amounts. The specifications for these cables are determined at conferences of the leading experts in telephone engineering. "The main object of paper cable is to obtain the lowest possible K. . . . What the lowest possible K under theoretical conditions may be . . . is, of course, very difficult to decide. To the best of the author's knowledge, no one but Dr. F. A. C. Perrine . . . has attacked the problem. . . . His experiments gave a result of ·0386 for dry air, which has the lowest K of anything known." . . . "The advantages of the low K are longer and clearer speaking distances . . . limited by the product of K into another factor, the C R or conductor resistance."

"We may lower R by using a larger wire, but this not only means extra expense, but by increased surface augments the K; for every wire must be considered as, and in fact is, a condenser. The smaller the wire, therefore, the more economical and lower the K, but No. 19 is the practical limit in size which can be handled with safety by the splicers under the difficult conditions often met with in the conduit manholes.

"So we may almost conclude that we have arrived at the practical limit of low K when we touch the higher sizes, and at ·065 the telephone engineers will have to turn their attention to other elements of their system, for they will then have wrenched the extreme of possibility from the already overstrained manufacturers. There *may* perhaps be a chance of finding a paper with lower specific inductive capacity than that now used; but if found, it is highly possible that it would lack necessary strength or other mechanical qualities."

Comparing the K R formula of the English postal officials with the actual results obtained on the New York and Chicago lines, Mr. Bishop is "tempted to inquire whether or not there exists some other factor hitherto unsuspected, which, when discovered, will bring the calculated values nearer to the true."

The Institution of Civil Engineers.—The following appear in a list of the awards made for original communications submitted during the past session:—The Manby Premium to Charles Butters and Edgar Smart, A.M.I.C.E., for their joint paper on "Plant for the Extraction of Gold by the Cyanide Process." A Crampton prize to John Richardson (of Lincoln), M.I.C.E., for "The Mechanical and Electrical Regulation of Steam Engines."

SOME FIGURES RELATIVE TO THE COST OF PRODUCER GAS.

By W. H. BOOTH.

The recent exaggerated figures of cost that have been put forward by Mr. Bollinckx and those associated with him, probably more for the sake of advertising their productions than as matters of serious fact, are, however, no less liable to mislead than if they had been advanced more seriously.

Mr. Bollinckx's contention is that producer gas cannot be produced for less than one centime per cube metre, and, taking this as a basis, in total disregard of all evidence as to the solid fuel consumption per horse-power hour already demonstrated by tests, he builds up his figures of annual cost. For the steam engine, however, he took simply the solid fuel consumption, whereas he ought in fairness to have placed himself in the hands of some gas engine maker and accepted from him a figure for the cost of steam per pound in the same way as he himself laid down the cost of gas per metre. He did not even enter into any argument as to the cost of working a producer or attempt to show that more, or more skilful, labour was required to manage a producer than to manage a high pressure boiler. Most engineers are satisfied that practically the labour item will not vary much, but our own impression is that it will finally be found in favour of the producer, the stoking of which is a matter requiring no dexterity, and the general danger of which is less than attends a high pressure steam boiler. Assuming at the present, however, an equality of cost, the question of relative economy resolves itself into one of gas production per pound of fuel and consumption per horse-power. For this purpose the following figures have been obtained from Mr. B. H. Thwaite who has given considerable attention to the question of gas production and whose duplex producer has been already noticed in these columns as presenting features which will in all likelihood make it an unequivocal success. Now Mr. Thwaite states that in everyday practice, from one ton of coal, the volume of producer gas may be counted as 3,500 m^3. or 123,600 cubic feet, and the consumption per brake horse-power may be averaged as at the most 90 cubic feet or say 2·55 m^3. At this rate one ton of coal will yield 1,373 brake H.P. The cost per m^3. of the gas, with coal at 9s. (about 11½ francs), is thus 0·301 centime. But for this purpose there is not required coal at 9s. Slack at 5s., under certain conditions, will equally work a producer plant and bring down the cost to ·171 centime per m^3. Still the higher figure is but three-tenths of Mr. Bollinckx's estimate and is thus sufficient to completely overturn his claims.

With the foregoing figures the consumption of fuel per brake horse-power hour is seen to be 1·63 lb. This is the fuel consumption without any attempt at recuperation from the inevitable wastes. It represents about $1\frac{4}{10}$ths pounds of fuel per indicated horse-power of a steam engine doing the same duty and consuming some 10 per cent. in internal friction. But the gross fuel consumption is too wasteful to be allowed in these days. It is not permitted in the steam engine to which have been applied in succession, the condenser, the feed-heater, and other means of absorbing some of the waste heat, both in the flues and at the hot-well. How far can such economies be practised in the gas engine?

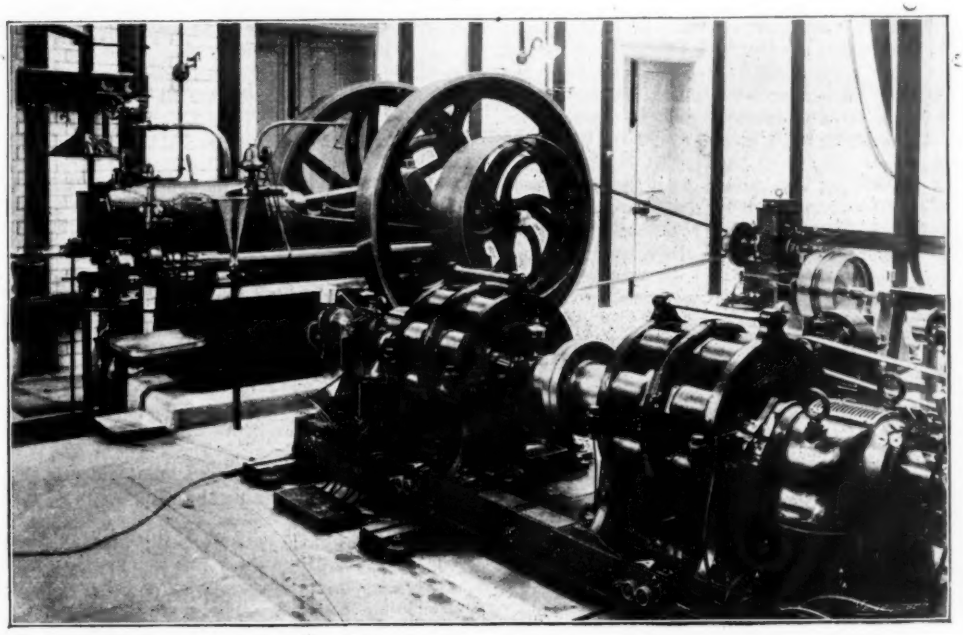
So far, no attempt has been made to employ any parallel to the economiser or other feed heater. In a gas engine with producer plant there are three chief sources of waste: (*a*) In the cooling pipes of the gas *producing* end; (*b*) in the exhaust from the working cylinder; and (*c*) at the water jacket of the working cylinder; this last about as irrational a waste as can well be imagined in a heat engine but necessary, in the present state of our practical knowledge, to secure the safety of the cylinder. The waste (*a*) is, of course, that due to the cooling of the gas as it leaves the producer. It is the loss of the 4,400 units of sensible heat produced by the first oxidation of carbon, and, the gas produced (C O) has thus left remaining only 10,100 potential units for further development.

It is easy to see that, as suggested by Mr. Thwaite, the cooling pipes may be cooled by the air blown into the producer. This air with the assistance of a little water

will have a powerful refrigerating effect, and all the heat taken up will be carried directly back into the producer where some moisture is desirable as a source of hydrogen, the oxygen set free being available for combination with the carbon of the fuel.

The maximum economy of this cooling is obviously $\frac{44}{101}$ or 43½ per cent. additional duty per pound of fuel, one-half of which, or let us say an economy of even 20 per cent. is a very desirable addition. Apart from the economy of heat which attends this regenerative system there is a further saving that is peculiar to a gas engine plant. We refer to the recovery of the ammonia and other residuals such as tar, &c. Mr. Ludwig Mond, the noted chemist, has published figures from gas producer practice, showing a production of sulphate of ammonia of 4 tons per 125 tons of fuel used, that is to say of 72 pounds of sulphate per ton of fuel, and though Mr. Mond, with special facilities, may be able to recover such a weight, it will be better in the present argument to take the figures shown by recent practice in Scotch blast furnace waste recovery plant, and this shows 24 lbs. per ton of sulphate worth £10 per ton, and 140 lbs. of tar producing 85 lbs. of pitch and 6½ gallons of tar oil worth 1¼d. per gallon. The value of the residuals per ton, taking the net value of the sulphate as £8, and leaving the pitch out of account, though it will more than pay for the cost of separating out the oil, will thus come to 24 lbs. sulphate at £8 = 1s. 8½d., and 6½ gallons oil at 1¼d. = 8¼d., a total of, say, 2s. 5d. per ton to be deducted from the original fuel cost. The recovery of residuals is applicable to all powers of 800 horse and upwards, smaller sizes of course not being commercially suitable for treatment. Taking coal at 5s. per ton, its net cost as chargeable to power is reduced to 2s. 7d. only, while if Mr. Mond's figures can be substantiated in ordinary practice, the recovery of the ammonia alone, would reduce the net fuel cost to only 1s. per ton. So much then at present for the recovery of one form of waste with so great a potential of manurial value. The cooling jacket round the cylinder gives heat to water, and this water may be compelled to return all the heat it absorbs in the shape of steam to be swept by the air blast back into the gas producer, or part of the water may be continually drawn off to mix with the air as it passes over the gas coolers, and in the same way the sensible heat of the exhaust can be absorbed and carried back to the producer. In the steam engine these aids to economy cannot be carried out by reason of the essential differences in the means employed to generate and utilise the heat of the fuel. It is therefore not unreasonable to expect an economy from the three named sources of at least 50 per cent. in additional duty per ton of fuel used. This would bring down the actual fuel consumption per brake horse-power hour to nearly one pound of coal of common steam quality. With this figure, and subtracting from the cost of the coal its selling value as expressed in recovered bye products, the consumption is reduced to about ¾ lb. per horse-power hour, a figure with which the steam engine cannot possibly compete, and at which we have arrived after subtraction of only ordinary rates of recovery of residuals, and an addition to power production of only 50 per cent. where the engine wastes alone, total up to about 300 per cent., and the producer waste to 43½ per cent. upon this; that is to say we have multiplied by 1½ in place of by 5¾ in estimating the economy due to heat recovery, but it is really too early yet to show a fuel consumption of less than ¾ lb. and further; the waste heat is so great in amount that for the moment the figures shall rest at what really amounts to a utilisation of one-fourth the heat of the fuel, because such a figure is so much less open to criticism, being well within the margin.

(To be continued.)



DESCRIPTION OF A MOTOR-ALTERNATOR MADE FOR THE ELECTRICAL LABORATORIES AT UNIVERSITY COLLEGE LONDON.

The illustration above shows the motor-alternator constructed for the new electrical engineering laboratories at University College, London, by Messrs. Johnson and Phillips.

The machine was designed by Dr. Fleming, and the details and calculations worked out by Mr. Kapp, the object being to generate alternating currents for experimental purposes by some means which should provide in the most simple manner for producing alternating currents of various frequencies, and also for generating two-phase currents from the same plant.

The plant consists of four separate machines bolted on to the same bedplate, two Kapp alternators and two continuous current motors. Each alternator is coupled direct to its own motor, the commutators of the continuous current machines being on the outside end of the shaft. The shaft is cut in the middle, and the inside ends carry a flange pulley. These pulleys can be coupled together through the flange by bolts, so as to drive the whole as one machine, or they can be separated for use as two machines. By coupling them together with armatures in the proper relative position, two-phase currents can be got out of the united machine.

Each of the continuous-current motors is 5 H.P. designed to work at 100 volts. The armature is ring wound, and

there are 216 turns of wire in it, connected to a 72 part commutator. The magnets of the motors are of cast-steel 6⅞ths inches diameter. Each armature can carry 35 or 40 amperes comfortably.

The alternator armatures contain an iron core, and are each wound over with 8 coils having 16 turns of wire. The field magnets have eight poles, and corresponding poles are opposite to one another. The alternators, when driven at a speed of 1,250 revolutions, give an electromotive force of 100 volts.

The four machines are carried on a cast-iron bed plate, 9 feet long and 2 feet wide, which is carried on slide rails in the usual manner. The ends of all the armature and field magnet circuits are brought to terminals fixed in a box on the front of the machine. In the field magnet circuit of each machine is an appropriate resistance, and in the armature circuits of the motors there are also resistances for starting the motors.

The field magnets of both motors and alternators are fitted with Johnson & Steel's patent potential arrestors, the function of which is to prevent the injury so common to the insulation of field coils when their circuit is broken.

Since it was delivered at the University College, two useful additions have been made to it by students working in the laboratory. One of these is a curve tracer, for tracing the form of alternating current curves, which is fixed to one outside end of the right hand machine, and the other to a hydraulic speed indicator, which is fixed to the outside end of the shaft of the left hand machine. This hydraulic speed indicator is of the form designed by Mr. Towers. A small centrifugal pump is driven by the shaft, and it pumps coloured water from a small reservoir placed over the pump through a pipe into two vertical glass tube pressure gauges, one of which is placed on the wall of the dynamo room, and the other of which is placed on the wall of the electrical laboratory 30 feet away. When the motor alternator is running, the centrifugal pump pumps the water up these tubes, until the hydrostatic pressure of the column of liquid supported in the tube balances the pressure due to the pump. The height of the column of liquid, therefore, can be made a measure of the speed of the machine, and these gauges have been carefully calibrated. The beauty of this hydraulic speed indicator is that it is so exceedingly responsive to changes in speed. A change in speed of less than 1 per cent. can be certainly detected, whilst the accuracy of the indication is independent of the density of the liquid used. The speed of the motor can therefore be regulated from the laboratory and kept exceedingly constant.

It will be seen that such a double motor-alternator plant can be put to a great many uses. The alternators can be driven separately or together. The electromotive forces and currents of the alternator can be added together as required, or a two-phase alternating current can be obtained from the machine.

As usually used, the motors can be driven off the St. Pancras electric lighting circuits, the speed being regulated by field resistances and the electromotive force of the alternator regulated by resistances in the alternator field magnet circuits. The machine is exceedingly useful in investigations on alternating currents, is a thoroughly excellent piece of work, and the construction lends itself to many forms of experimental testing useful in a teaching laboratory.

SOME PHYSIOLOGICAL EFFECTS EXPERIENCED IN CONTACT WITH LIVE ALTERNATING CURRENT CIRCUITS.*

By LUDWIG GUTMANN,
Member American Institute Electrical Engineers.

Since one of the topics of the day is the effect of the electric current and especially alternating current on the human body, it may be of interest to throw some further light on this question, and on those unfortunate beings who find themselves unintentionally or otherwise in the grasp of this mystic power. So far, no one who survived has satisfactorily explained his feelings and it might be supposed erroneously, that everybody would be unconscious as soon as he had established connections with a live circuit.

Having had a number of men under me doing work on such circuits, I have tried to find out from those who have experienced severe shocks what they had felt, but received replies from which no logical conclusions could be derived, with one exception, namely, regarding the length of time they believed they were in the circuit. I have found invariably that men caught on alternating current circuits would estimate the length of time of contact a great deal longer than could be accounted for, and their statements have been contradicted and disproved by others near at hand at the time of the accident. A man who had formed part of a circuit would say, he believed he was in circuit for ten minutes, when the whole time may not have been more than as many seconds, or at the outside half a minute as learned from the statement of others.

While trying to unravel this mystery, which I began to think was not intended to be known to man, the means of acquiring the information were accidently placed in my way.

It happened this way:

My experimental room was located on the first floor of the factory and divided from the main part in which light machine work was done, by a low partition. There were some 40 or 50 men engaged on this floor, filing, hammering, fitting, turning, &c., &c.

The dynamo utilised for testing was on the ground floor, and the switch controlling this, a special circuit, temporarily arranged and brought to my room, was between my room and the transformer test-room. Having finished some determinations regarding a new type of transformer, I went out and opened the switch and returned to my room. Then I carelessly opened the connectors, not expecting that on my return to the room somebody else would close the switch again, which proved to be the case in this instance. On getting hold of the primary wire of the transformer with one hand and the circuit wire with the other and pulling them out apart from the connectors, I placed myself directly in the high tension circuit. I was caught, the bare ends of the wire were held one in either hand, which, by the flow of current were closed, holding the wire, a No. 8 or 10 B. and S., tightly in the hands.

For an instant I was stunned; when this momentary unconsciousness passed away I found myself unable to breathe, utter a cry for assistance, or move, I was spell-bound in a crouching position. The noise around me in the shop seemed to be very weak, it was as if I was a block or more away and the hammer blows which generally made the shop so noisy were very faint. I was not capable of thinking about myself, and the danger in which I was placed. All I do remember besides the faint hammering was, that I felt my arms shaken as if in the grasp of some powerful man, in a playfully exaggerated hand-shake.

I felt the rolling action of the current impulses, as they slowly approached, just as we observe the heavy waves approaching the shore on the beach.

Suddenly the wires had burned through the skin and in some way did not make proper contact, the current was momentarily interrupted and I jumped up, or as this motion was a passive one on my part, I was straightened out from my bent position by the relaxation of the muscles, while in doing so the dangerous wires dropped to the floor.

I was free once more, and after taking a deep breath I felt a glowing heat all over my body and a weakness in the limbs, just as after a fainting spell. In spite of this trouble, which had not been noticed by anybody, I continued to work, feeling ashamed of having been caught in that way. The dynamo was a 10 pole alternator, yielding at the time 1,100 to 1,150 volts while my body was in series with the primary coil across the terminals of the generator.

With this unexpected experience at my disposal I have been able to explain a number of sensations. Of course I must admit that the current was weak enough and the conditions favourable enough (for me) to recollect, but I believe that it was very near the limit. I could neither breathe, utter a sound, move, nor was I capable of thinking anything except the sensation to which I was subjected, as no other thoughts, not even fear for my life or knowledge of my predicament, entered my mind at any time. All such ideas must have

* *Electric Power.*

been dormant. This experience occupied my mind in my leisure moments and I asked myself: Could you not have counted the alternations had you thought of it, especially as every impulse seemed so clear and distinct, such a slow rolling motion, starting in the hands and creeping up the arms, with such a long time apparently between the waves?

At first I thought I could have done it, but later, I came to the conclusion that to experience and feel every impulse distinctly is one thing; and to remember, record or integrate is an entirely different thing, leaving out of consideration the fact that the concentration or retention of such a thought of counting or attempting to count would be a questionable, if not an impossible, task under the influence of the current.

We can understand why some people think the sensation is like that of being beaten, or why I felt the severe hand and arm shaking. It is simply the result of the current on the muscles which alternately assume a state of contraction and relaxation. The strange fact that men believed to have been in circuit a considerably longer time than was actually the case can now also be accounted for; evidently, if you can clearly distinguish every impulse, the brain must be capable of counting 16,000 in a minute, even if we are not able to mechanically record it. Under these conditions a quarter of a minute would mean counting mentally to 4,000, and any man would naturally think the time must be more than five minutes.

The very fact that men have made such statements with the error in the same direction, clearly shows that they were not unconscious but that some *part* of their brain was temporarily disabled or paralysed.

Dr. Goelet's conclusions, derived from the examination of the body of the murderer Hampton at Sing Sing and published in the *Electrical World* of March 16th, are very logical. They should, however, not be used in a general way. There is a vast difference between an accidental contact with a live wire, and especially prepared connections for executing criminals. His conclusion, however, that death is painless because "electricity travels faster than the nerves can transmit painful impulses," seems to me erroneous believing that three times the number of alternations as used at present can still be clearly distinguished by the brain.

Death may be instantaneous, if a large amount of energy is suddenly discharged through the body; it can be painless also when the apparatus is less powerful and properly applied; because a sufficient amount of energy used, while it may not cause instant death, will produce contraction or expansion of parts of the brain either by direct action of the current, or more probably by the pressure of the blood vessels on the surrounding portions of the brain, causing instantaneous unconsciousness, while death results ultimately from the decomposition of the blood; or, as these investigations have also disclosed, by the bursting of blood vessels in the brain, with their well-known effects.

The statements made by Prof. D'Arsonval have proved to be incorrect as regards the executions in New York State, yet the controversy he has caused has been of incalculable value, for it has been the cause first of establishing the truth, and secondly to restore to life those or many of those who accidentally have fallen into the grasp of this invisible force. It is gratifying to know that, owing to just these controversies and the resultant instructions given, a number of hapless victims have been restored to life by artificial respiration.

THE TELEPHONE SERVICE: PARLIAMENTARY INQUIRY.

(*Continued from page* 694.)

The Committee resumed its sitting on Friday, Mr. Arnold Morley, Postmaster-General, presiding.

Mr. J. S. Forbes resumed his evidence-in-chief. In order to test what truth there was in the assertion that the telephone service was inefficient, he put in a statement showing the local messages (exclusive of trunk messages) for one day—the 3rd of April last—passing through the exchanges at Glasgow, Aberdeen, and Edinburgh. This showed that in Glasgow out of a total of 69,406 messages, 59,020 subscribers were placed in effective communication under half a minute, 4,590 under one minute, 974 under a minute and a half, 698 under two minutes, 260 under two and a half minutes, 572 under three minutes, 54 under three and a half minutes, 326 under four minutes, 218 under four and a half minutes, and in 2,694 cases it took five minutes or more to put the subscribers into effective communication. All those exchanges were, he said, subject to common user, and, of course, a subscriber to an exchange could not expect to be in the same happy position as a man who had a private wire. In Aberdeen, out of a total of 15,054 messages, 14,050 subscribers were placed in effective communication under half a minute, 490 under one minute, 394 under a minute and a half, 66 under three minutes, and 54 under five minutes. In Edinburgh, out of a total of 19,602 messages, 12,130 subscribers were placed into effective communication under half a minute, 1,956 under one minute, 1,298 under a minute and a half, 1,428 under two minutes, 628 under two and a half minutes, 1,018 under three minutes, 110 under three and a half minutes, 250 under four minutes, 34 under four and a half minutes, and in 750 cases it took five minutes and over. He thought those figures disposed of the assertion that the service was inefficient, and could not, therefore, be used to advantage.

By the Chairman: Can you tell us the number of subscribers at Glasgow, Aberdeen, and Edinburgh?—5,221 at Glasgow, 1,741 Edinburgh, 1,029 in Aberdeen, and in London 10,848.

Then we may take it that on this one day in Glasgow the 5,221 subscribers used the telephone 69,000 times?—Yes.

And the same as regards Aberdeen and Edinburgh?—Yes, that is the number of calls in one day.

Showing a very considerable user of the telephone by the subscribers?—Yes; an effective call means a call which results in the person called upon being able to speak to the person calling. In London, at the Queen Victoria Street exchange, the statement he had had prepared showed that the number of messages dealt with by one operator in charge of 50 subscribers during seven hours—10 a.m. to 5 p.m.—on April 3rd last, was 508, and the time occupied in placing the subscribers into effective communication was under half a minute, 176; under 1 minute 146; under 1½ minutes 116; under 2 minutes 20; under 2½ minutes 34; under 3 minutes four; under 3½ minutes eight; under 4 minutes two, and two under 5 minutes.

The witness then handed in a return of local messages through a few important exchanges on the company's system, exclusive of trunk messages. This showed that in Leeds there was 40,000 messages on one day, giving an average of 26 messages for each subscriber, at a cost of under a farthing. At Liverpool there were 96,644 messages, an average of 26 for each subscriber, at about the same cost.

The Chairman: I notice that in London the charge is more than double the highest figure on your list. How do you account for that fact?—Because in London it is much less used than in some provincial towns.

And is that due to the fact that in London the charges are high?—No doubt the charges are high in London.

By Mr. Benn: The greater the business done the less the charge?—The figures point to that—that is to say, the more the capacity of the machine is worked, the less charge per user.

By the Chairman: If there are two subscribers paying the same annual amount, and one subscriber uses the telephone much more freely than the other, the man who uses it more freely is charged less per message than the man who uses it less frequently?—That is so.

Are these figures as to Leeds and Liverpool, and the others which are given on the statement, average specimens of towns all over the country?—Yes; they are put forward with a view of being tested, so as to give the Committee, as near as we can ascertain, the real facts, against the statements which have been put before you.

Is Glasgow included?—Yes.

And I see the cost per message comes out at little over a halfpenny there?—Yes.

Witness then put in the following comparative statement of telegraphic service of certain European countries, with ratio per head of population, extracted from the *Journal Telegraphique*:—

	Grand total of telegrams.	Population.	Telegrams per head.
Russia	13,193,257	120,000,000	·109
Italy	9,681,912	30,347,291	·319
Roumania	1,649,294	5,040,000	·327
Hungary	6,522,302	17,349,398	·375
Sweden	2,101,850	4,824,150	·435
Austria	12,068,064	23,895,413	·505
Germany	33,172,116	49,428,470	·671
Denmark	1,817,718	2,172,380	·836
Norway	1,740,180	2,001,000	·869
Belgium	5,414,864	6,069,321	·892
Low Countries	4,429,771	4,732,911	·935
France	47,017,117	38,343,192	1·226
Switzerland	3,838,323	2,917,819	1·315
Great Britain and Ireland	73,299,237	38,520,116	1·902

The witness then handed in another statement, showing the number of lines and population at various centres throughout the United Kingdom at December 31st last. The following is a summary of the statement:—

Centres.	Number of lines.	Population.	Population per line.
Scotland	12,661	1,607,775	127
England and Wales ...	57,358	16,632,254	290
Ireland	3,319	810,469	244
Total	73,338	19,050,498	260

That return, the WITNESS said, went to prove that, considering all the drawbacks the company had had to contend with, they had not made such slow advance as had been asserted. London was almost the worst in respect to the population per line, or to put it another way, it was worse than Canterbury. There must be some reason why London was so behind in the use of the telephone, and that was the object of that inquiry.

Witness then handed in the following statement, showing the number of subscribers on the metropolitan exchange having a limited local service, and the number of subscribers on the same exchanges having full metropolitan service:—

	No. of subscribers to local service at £10 per annum.	No. of subscribers in same exchanges having full Metropolitan service.
Croydon (the local service includes free speaking between Sydenham, Bromley, Redhill, Epsom, and Streatham)	61	250
Kensington	3	342
Kingston (including Richmond and Wimbledon)	2	36
Battersea	1	67
Eastern	3	279
	70	974

Number of private houses connected in the metropolis ... 492

That statement, he said, seemed to show that the local service was not greatly appreciated, for to take the case of Croydon, although they had had canvassers there who had pointed out to the people the great advantage of the local service, they had only been able to get 61 subscribers at £10, whereas in the very same area they had 250 subscribers to the exchange who paid the London price.

By the CHAIRMAN: How much would those local subscribers who pay £10 a year for a limited service, have to pay if they wanted to communicate with the other subscribers in other portions of the metropolitan area?—They would have to use the call office, and pay for a second message.

Continuing, he said that in Battersea, which was supposed to be the working man's paradise, they had managed to get one subscriber. That he thought exploded the fallacy that the telephone was a working man's necessity. He did not suppose one working man in a thousand would ever require to use the telephone.

In reply to Mr. SNAPE, the WITNESS said he did not suppose the necessities of a working man would lead to his requiring to use the telephone once a year.

Would not the small shopkeeper or tradesman use it?—That is coming nearer home. Surely it is worth while a small tradesman using a thing which he can have the reasonable use of, day and night, for 6d.

Mr. BENN: Not the London tariff.

The WITNESS: It is a little more in London.

Mr. BENN: Twice as much?

The WITNESS: No, not twice as much. Continuing, he said the agreement would certainly encourage the multiplication of call offices, and would also encourage telephoning. It would also increase the subscribers to the exchanges, and then anybody who chose to rely upon the call office could pay a fee.

By the CHAIRMAN: These are results which you think will accrue from the agreement?—Yes.

The agreement has not been operative, so you have had no actual experience?—No; but I have no doubt of the result.

Continuing, the WITNESS said that there were a great many people in London—professional men and others—whose interests in the telephone were not so great that they were prepared to pay the average rate of £14 per annum, and, therefore, to anybody who chose to take it, they offered a private house connection in the metropolis at a charge of £10, and, as his statement showed, they had 492 of such customers. They had, he said, got to try and persuade the public that telephoning was so extremely cheap and relatively efficient, that it would be to their advantage to subscribe.

By Mr. SNAPE: How many of these 492 are business people, and who subscribe from their business premises?—I will get that information for you, but I think it will be found that the people who use this service are solicitors, Parliamentary agents, people at Westminster or in the City, who in their business have no particular call for telephoning, but to whom it is an advantage to be connected with their private houses.

You have not many householders who use the telephone?—No.

And is that not because the charges are too high?—No; 6d. a day cannot be too high. Neither was it, continued the witness, due to the inefficiency of the service. Even in Germany, with all the perfection of the service, people sometimes had to wait their turn. They were disciplined to wait, but Englishmen were not.

Witness then handed in a comparative statement to the Committee of the National Telephone Company's and the Post Office subscribers' lines, giving in each case the number of subscribers at the opening and the number at the end of last year, which he said showed that while the Post Office was more or less stationary, the telephone company had made an advance. He then put in the following statement as to the relations between the company and the Association for the Protection of Telephone Subscribers in London:—

After the decision had been arrived at that the proposals of the New Telephone Company for working a separate telephone system in London under the conditions set forth in the agreement between the New Telephone Company and the Association for the Protection of Telephone Subscribers, dated April 25th, 1892, could not, with advantage to the public, or with any prospect of financial success to the New Telephone Company, be given effect to, and that in the interests of all parties concerned it was expedient, in order to secure a more efficient service than then existed, to remodel the plant of the National Telephone Company on the metallic circuit principle, negotiations took place between the representatives of the Association and of the National Telephone Company, with the result that certain assurances which were given by the National Telephone Company, accompanied by certain modifications of tariff, were accepted by the Association as a fulfilment of the obligations of the New Telephone Company to the Association, as set forth in the said agreement. The assurances referred to were that the National Telephone Company would continue the work then in progress, of remodelling its London system upon the metallic circuit principle, and that work has been pushed forward with the utmost vigour, in redemption of the pledges given upon the conclusion of these arrangements. The following letter, signed by the representatives of the Association, was sent to the London Press, and appeared in the *Times* of March 20th, 1893:—"Sir—We hope that you will allow us to inform the telephone users of London through the medium of your journal that, as the direct result of the pressure brought to bear upon the National Telephone Company by the Association for the Protection of Telephone Subscribers, the prices of private house telephones in London, giving communication over the whole metropolitan area, will be almost immediately reduced from £20 a year to £10 a year, subject only to the condition that they are taken upon a five years' contract. The price of business telephones will remain as at present, but since the National Company have promised immediately to instal the twin-wire system, which will make speaking on the telephone clear and easy, the chief objection to entering upon five years' contracts for business telephones and taking the discount of £3 per annum then allowed, vanishes. Had the New Telephone Company continued to have an independent existence, our association had great hopes of obtaining an even better telephone service than has now been secured to users; but, on the other hand, it must be remembered that these benefits would have been seriously discounted by the fact that it would have been two or three years before the New Telephone Company would have been in full working order, while the present advantages will be secured immediately.—Yours truly, C. R. HAIG, A. H. HASTIE. 65, Lincoln's Inn Fields, W.C., March 17th."

By Mr. BENN: There is nothing in that letter to show that if the New Telephone Company had continued, that it would have failed to carry out its financial promises with regard to rates of subscription and service?—No; but Mr. Hastie is not a man who would take a mere assurance, but would thoroughly satisfy himself on that point. We were convinced that the scheme of the New Telephone Company was impossible; that it would involve a large waste of capital. Witness, continuing, said that they were able to satisfy the Duke of Marlborough that what the New Telephone Company aimed at could be equally well done by the National Telephone Company, and they had already gone a long way to realise those aims. What they wanted was the principle of metallic circuit in London; and, secondly, a reduction in prices. The reduction in prices had taken place, for, instead of £20, the cost was only £14 odd, and in London alone they had spent £200,000 in the metallic circuit.

Examined with reference to the estimate put in on behalf of the London County Council, the WITNESS put in a statement regarding the new and ceased subscribers to the company for the year ending December 31st last. That, he said, showed that in the year the new subscribers numbered 12,502, and in the same period 4,410 ceased to subscribe. That involved an enormous sum of money in waste. In a great measure the falling off of subscribers was due to the commercial depression.

By the CHAIRMAN: What, on an average, does it cost you to put an instrument into a subscriber's house?—In London, £55. That, continued the witness, included all expenses. About £25 would represent the actual cost of attaching each individual subscriber, over and above the contribution, which, as a subscriber, he would have to contribute towards the central administration. So far as he had examined the estimate of the London County Council, no account was taken of the great waste which was constantly going on; or if it was taken into account, he did not think the estimate very reliable.

By Lord STANLEY: In this number of subscribers who went off, did any of them write and ask if they could have a less limited exchange at a cheaper rate?—It is just possible one or two may have so written, but it would be in infinitesimal proportion. The incidence of the business involve a certain number going off each year, and people who draw up estimates ought to take that into account.

WITNESS then gave his opinion of Mr. Newland's estimate, remarking that it was altogether hypothetical, for it was based on 40,000 £10 subscribers, and it would take a considerable time before that number could be reached. It was true that he, himself, had put forward a somewhat similar estimate some years ago, but actual experience had taught him that it could not be relied on.

WITNESS was next examined on the prospectus of the New Company, and, in reply to Mr. BENN, said they arrived at the fact that the figures in that prospectus were fallacious by argument, deduction, and conviction. The National Company put £250,000 into the New Company, and had representation on the board. It was thought to be more efficient to carry out the suggestions by the machinery of the National Company. He put his name to the prospectus with all his practical experience gained from the National Company, but it was a matter they considered it worth their while to go into.

Mr. BENN: My point is that in 1892, with all your experience of the National Company, you signed the document, and you brought out the estimate?—We were in hopes that Mr. Bennett and Prof. Silvanus Thompson were right, but we found on examination they were wrong, and we found there was a more economical way of doing the same thing, and we have done it.

What additional information did you derive, from a practical point of view, at the date of amalgamation, other than the information you

had when you signed the document?—We hoped that Mr. Bennett and the Duke of Marlborough might be right, although we knew what they said was contrary to our experience. But we persuaded them that we were right and they were wrong, and they were not prepared to go on with it, because they were satisfied that these estimates were misleading.

You had taken the precaution to absorb most of the capital of the New Company?—No; we had not then. We had subscribed £25,000; it was worth our while to do that to ascertain whether we were right or wrong.

Is it not right that if they had proceeded with their enterprise it would have seriously affected your subscribers and your profits?—No; I don't know that it is.

Sir CHARLES CAMERON next examined the witness, taking the statistics of Stockholm and comparing them with London. Mr. FORBES said it was impossible to compare the two places. There were more subscribers in Stockholm than in London. Unfortunately, the accounts of the Stockholm Companies did not show what the way-leaves cost. In London they cost £1 13s. 4d. per subscriber. He was aware that there was a great extension of public call offices in Stockholm, and that the rate of charge was 1½d., whilst in London the charge was 3d. In Brighton, Leeds, Portsmouth, Newcastle and other towns, the charge was 1d. Newcastle was a place where they had post office competition, but he did not know the Post Office charges.

Sir CHARLES CAMERON: You have shown the absolute absurdity of Major-General Webber's proposal of sub-dividing exchanges. Are you aware that system has been adopted in Stockholm?—I did not suggest anything of the kind. I merely said that what he said was contrary to our conviction.

I admit the absolute right of your company to carry on its business in any way it thinks proper; but I maintain that it is for the public good to have competition, and that competitors should carry on the business in any way they like. I ask you if the system of Major-General Webber is being adopted in Stockholm?—I can't say.

The Post Office have made their own terms under this agreement?—Yes.

And they reserve to themselves the right to grant licenses?—Yes.

Mr. Lamb has told us that the Post Office have in no way departed from their freedom to grant licenses?—They are absolutely free.

You agree that there is not even a nominal engagement on the part of the Post Office not to grant licenses?—They are absolutely free. In all the negotiations there has never been the slightest sign on the part of the Post Office of letting go of their monopoly. From the beginning that has been strictly observed.

Continuing, WITNESS said that the wages of the lady telephone clerks in the employ of the company varied from 5s. for young understudies, who had to be taught, up to 17s. That was less than was paid in some places, and more than was paid in others. They worked eight hours, with an hour interval for meals. As far as mechanical labour was concerned, that was at least 33 per cent. higher than anywhere else. The dividends paid by the company were their first 3½ per cent. debenture stock; a small number of 6 per cent. first preference shares; a considerable quantity of second preference at 5 per cent., and they paid a steady 5 per cent. on the ordinary shares. He believed the General Company in Stockholm paid 8 per cent.

The CHAIRMAN: Is the Stockholm Company limited to a term of years?—I do not know.

By Sir CHARLES CAMERON: They had put by £320,000 to their reserve fund. They had no sinking fund so named. They did not call the reserve fund a sinking fund, but if they sank there was a fund. They put away about £60,000 a year, but it was not worked out at a ratio with reference to the expiration of the license. No one could tell what was going to happen to the business before 1911. Of course, if at the end of that time the whole of their capital was lost, it would be a serious thing, but they could not contemplate such a thing happening. The total capital was about £5,000,000.

Mr. Preece gave us a number of reasons against competition in telephone areas, and, amongst others, he pointed out that there would be a great inducement to a strong company like yours to go in and undersell a competing company by cutting rates. That course was pursued in Plymouth, but you repudiate the responsibility for that?—It was a small local company at that time.

Had the company any other sources to help it except Plymouth?—No.

In the case of Glasgow getting a license, Mr. Preece assumed that a strong company like the National Telephone Company would come down and cut its rates. Do you think that could be done if the Postmaster-General adopted a policy of granting licenses all round?—I can't answer for the Postmaster-General. If the Postmaster granted licenses, and the licensees could get over the difficulties of raising money without any agreement as to what will happen in respect to the concern in 1911, I should wait and see what they did.

You think they can't, and won't get over the difficulty of raising capital on the same terms as your company?—I think so.

Therefore, is there any reason for the Postmaster refusing to grant licenses to responsible bodies like the Glasgow Corporation?—I think that the Postmaster-General would be justified in considering the point whether the Corporation was likely to raise the money upon equal terms. Of course, if the Corporation decided to enter into competition regardless of profit and loss, that would be a different thing.

We will put aside the question of loss; they consider they could do it without going on the rates?—I am certain, as regards an attempt to raise money on the same terms as ourselves, it would be utterly impossible.

Well, they are equally sure apparently that they could carry out the intentions embodied in their application, and I presume that is a matter which could be left to settle itself by public opinion and the money market?—That is one way of settling it. Parliament might not feel inclined to authorise a Corporation to go into a thing of that sort. My natural bias is against granting licenses. If licenses are given for the purpose of driving the company out, it is not a creditable ground for application.

You promised to get us some figures relating to Dundee. Dundee, next to London, is the best telephoned town in the kingdom?—WITNESS said that the Dundee Company opened about June, 1880, and the National Company's exchange was opened in Dundee about July, 1881. The number of subscribers to the Dundee Company at the date of purchase was 332, and the number of subscribers to that company when the National Company commenced was 165. The number of National Company's subscribers at the date of purchase was 642, and the number of National Company's subscribers who were also Dundee Company's subscribers at the date of purchase was 152. Those figures did not coincide with those stated in evidence by Sir John Leng.

Sir CHARLES CAMERON: You admit the result of competition was to cut down prices?—Yes.

That it largely cut down prices, and largely increased the number of subscribers?—We progressed more rapidly than they did, notwithstanding the competition. But their whole system was so flimsy, that after we had purchased it we had to take it down. The result was the company got a good profit on a thing which we were obliged to pull down.

When the competition started the prices were £15 or £20?—It was really taken over by the Scotch companies, which we afterwards absorbed.

But the effect of the competition was to bring the prices down to £5 and £5 10s.?—Yes. The Dundee Company as a matter of fact started first.

WITNESS was next examined by Sir CHARLES CAMERON respecting a letter sent to the committee by Mr. Provand, M.P., in regard to the Mutual Telephone Company of Manchester and the telephone system in that place. He admitted that there was a deed between the Mutual Telephone Company and the New Telephone Company which absorbed it, binding the New Telephone Company to carry out the system at low rates in other towns. Manchester was telephoned for £8 in the district served by the Mutual Company, but the rest of Manchester was served at a higher rate. The Mutual Company made a bargain with the New Company which secured low rates for a limited service in Manchester, but the agreement utterly failed in its carrying out, for it was not appreciated by the Manchester people. The National made greater progress with their subscribers at the high rate than the others at the low rate, and a great many people who were persuaded to join at the low rate became subscribers to their high rate.

Sir CHARLES CAMERON: I am dealing with the obligation of the new company to establish twin wires and telephone exchanges in other towns at low rates?—I must respectfully decline to discuss that matter further. The affairs are in the hands of the liquidator, and questions under that head will most likely be the subject of legal proceedings.

The Mutual Company did not start in any town?—The Mutual Company sold itself to the New Company.

But the New Company took over the Mutual Company subject to the agreements with the Mutual Company; that is the allegation of the chairman of the Mutual Company?—I cannot agree to that. As to the allegation of the chairman of the company I cannot express any opinion on that. This is a very unfortunate position to put me into. These facts may be made use of in litigation hereafter, and, therefore, I would like to reserve any statement, as I have no right to prejudice the position of my company in answering questions, even to the Parliamentary Committee.

Sir CHARLES CAMERON: I do not think the production of documents which will have to come before a legal tribunal can prejudice that case.

WITNESS: I would respectfully like to know the view of the Committee; whether I should be compelled to produce these documents which will probably be used in a case of law?

The CHAIRMAN: You object to produce certain documents which you have been asked to produce, on the ground that they may prejudice the National Telephone Company, which you represent, in possible litigation hereafter?

WITNESS: Yes.

The room was cleared and the matter discussed in private, the announcement subsequently being made that the Committee had adjourned till Tuesday.

INTERIOR CONDUIT WIRING.

As so much interest is now being taken in the matter of conduit wiring, we describe what is known as the London and Lancashire Electric and General Engineering Company's fireproof and watertight system of wiring in iron tubes, a main feature of which is the adoption of special joint boxes (Russell's patent). The patents are the sole property of the company, who have now been operating the system for about two years, and claim to have proved that it is by far the best conduit system in use at the present time, and the only one having great mechanical strength.

The advantages of this system are said to be:—1. Great mechanical strength. 2. Waterproof and fireproof qualities. 3. It can be embedded in cement and plaster. 4. It is easy of erection.

The company having had considerable experience of conduit wiring are convinced that it is the system of the future.

The use of paper or composite tubes has been proved to be insuffi-

cient in themselves as regards mechanical strength, and to cover them with any kind of armour, adds considerably to the cost. Iron tubes have been adopted as being the only satisfactory material that will withstand the rough usage met with in practice, and something that a nail or screw cannot be driven into.

The tubes, which are coated inside and out with preservative compound, to prevent oxidation, are connected in the ordinary manner by screwed ends, sockets, &c., which call for no special tools other than those used by gasfitters.

The system has been carefully thought out, and patent drawing in boxes are used where necessary. As regards insulation, no trouble is experienced in maintaining this satisfactorily, and the wires when once drawn into tubes, cannot be damaged unless under most extraordinary circumstances. A difficulty which presents itself in all continuous conduit systems, is that of making joints, so that when finished they will be thoroughly satisfactory and well insulated from each other. This difficulty has been met by the use of a special form of patent joint box which has several distinct features, as will be seen from fig. 1.

Fig. 1.

The box is of metal and circular in form, having either 2, 3, or 4 ways at right angles. A and B are screwed suitably for tubes carrying mains, while C and D are used for branch wires; in the centre of box is fitted a centre pin or stud, which serves two purposes: first, to keep the porcelain insulators in place and, secondly, to allow of fixing a watertight cover. Previously to the mains being drawn in, a porcelain bottom plate is slipped in the box, mains are then drawn in and two very short pieces of wire jointed on of sufficient length to allow of their being brought up through holes in an upper porcelain plate, which carries double-pole fuse terminals (the illustration practically explains itself), and it will be seen that by this arrangement *the crossing of wires at joints is avoided.* Perfect insulation being obtained by the joints being sandwiched in between the two porcelain plates. The top surface, as will be seen, is provided with double-pole fuses, easy of access, the box and lid before being sent out from works, having been machined, a perfectly watertight joint can be made if required, the central stud allowing of an equal pressure all round the lid.

In cases where it is found necessary to examine the fuses frequently, glass lids may be used so that fuses can be examined without removing the lid.

The form of drawing-in box used is shown in fig. 2; this is a cast metal box (patent) screwed to receive tubes, and fitted with similar centre stud and cover, as provided for joint box, the special advantage

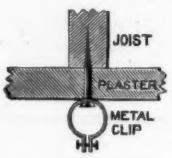


Fig. 4.

in this case being that when drawing in wires a wooden roller can be slipped over the centre pin, thus allowing the wire to run over easily and facilitate the drawing in.

Generally speaking, the system lends itself to being installed during the erection of new buildings, as the iron tubes may be put under floors, embedded in walls or cement without injury, drawing-in boxes being used where necessary.

It may be pointed out that should it be required to have a D.I. box on a wall of a room, it can be embedded flush, with the exception of the cover, which being of circular form and held by one screw or nut, can be easily decorated if necessary; in the case of heavy mains, boxes are provided with holes screwed for fixing tubes at obtuse angles in order to round curves easily.

In arranging an installation, the current from main switchboard is divided up into sections of 20 to 30 ampères, and pairs of mains run to distributing boards, where the current is split up into 5 or 10 ampère circuits for supplying lamps; the distributing boards having switches and double pole fuses mounted on enamelled slate, which rest on projections in a rectangular iron box, fig. 3, with glass front, an air space of about an inch being left at the back of slate to allow of branch mains being brought in easily.

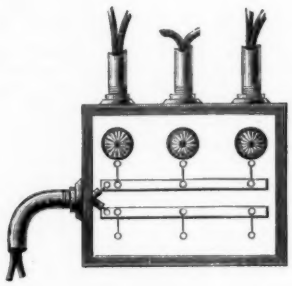


Fig. 3.—Fire-Proof Distributing Box.

The system which has now had a thorough trial, and, we understand, has been proved to be perfectly successful, is the design of the company's engineer, Mr. C. N. Russell, who is a strong advocate for conduit wiring, and who has carried out a number of installations with success; the system is suitable for all classes of work, and in addition to many others, the following installations which have been fitted with this system will show the varied character of the work for which it is adapted:—

Grand Junction Canal Company, Engineering Works.
" " " Steam Launch.
British Paper Company, Paper Mills.
J. Cartland & Sons, City Offices.
Messrs. Heelas, Sons & Co., Reading, Drapers and General Furnishers (6 arcs and the equivalent of 900 8-C P. incandescent lamps).
Messrs. John Howell & Co., Limited, St. Paul's Churchyard.
&c., &c.

The last two mentioned were to the specification of Mr. Albion T. Snell, consulting engineer to both firms.

We are informed that the system has been critically examined by the leading fire insurance companies, who express their approval of the system. The makers also state that it has frequently come before the notice of Mr. Heaphy, of the Phœnix Fire Office, and no difficulty has been experienced in getting the work passed. There are many other items, such as switch boxes, ceiling rose boxes, &c., in connection with the system which we are unable to describe more fully for want of space, but we may mention one that is worthy of special notice, and that is a method of fixing tubes to ceilings with clips requiring only one screw.

Fig. 2.

As most practical men know, it is very difficult in most cases to find in plaster ceilings good fixings for 2 screws for the ordinary brass saddle, and Mr. Russell has got over the difficulty by a clip of special design (see fig. 4) requiring only one screw to fix. Its good points will be at once apparent without further comment on our part.

THE ELECTRICAL LABORATORY OF THE CITY COMMISSIONERS OF SEWERS.

The City of London, being distinct from the administrative county, may be expected to possess a well-equipped electrical laboratory for carrying out the provisions of the Electric Lighting Acts and the Rules and Regulations of the Board of Trade, with regard to meter testing and the supervision of lines and mains vested in the local authority. In addition to this, the Commissioners happen to be large consumers of electrical energy in their capacity as the lighting authority for the City area, and this is in itself sufficient to vest the question of testing with some importance. The equipment provided is, therefore, of interest, and being the most recent established laboratory of the kind, one naturally expects to see the most modern ideas carried out in such a way as to make the arrangements a model to other corporate bodies thinking of exercising their powers. The City, again, may be taken as the most important lighting area in the kingdom, and the additional duties imposed upon the electric inspector by the existing lighting contract between the Commissioners of Sewers and the City of London Electric Lighting Company are by no means light.

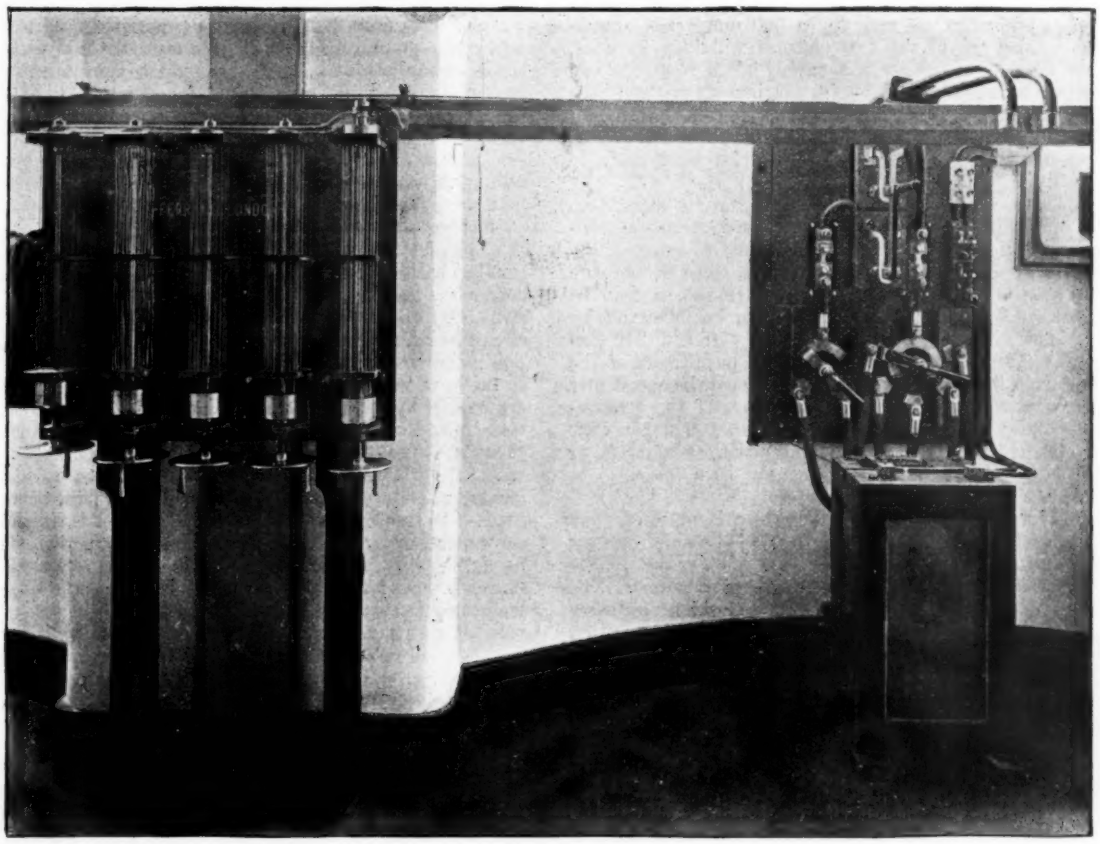


Fig 1.—View of Transformer and Switchboard.

The existing premises devoted to Mr. Voysey's department are not intended to be the permanent quarters of the electric inspector. New offices are now being built in Basinghall Street as an extension of the existing premises belonging to the different branches under the control of the Commission. At present, temporary accommodation has been provided in the basement of the Wool Exchange in Basinghall Street. This faces the side of the Guildhall, and is opposite to the main offices, so that it is convenient, while the position is a very suitable one for such a purpose as this. The windows look out on Basinghall Street, and afford ample light, while the basement character of the laboratory does away with much of the trouble so often met with owing to vibration originated by vehicular traffic in neighbouring thoroughfares. A room 29 feet by 23 feet forms the laboratory, and Mr. Voysey has designed his testing arrangements in as simple and inexpensive a way as possible, having in view their temporary character. The room was, however, very well adapted to the end in view, and required little or no structural alteration, therefore the fittings have been readily adapted to the reception of instruments, and should prove very convenient.

Meter testing is expected to be the chief work of the laboratory, and the principal arrangements have been made for that purpose. Current for testing purposes is taken from the street mains of the City of London Company. The three wire system enables the current to be taken off at a pressure of either 100 or 200 volts. For meter testing a high pressure is not necessary, if a number of coulombmeters—such as the Schallenberger—have to be tested, it is sufficient to obtain current at an electromotive force which allows for the fall of potential in the meters, in the measuring instruments, and in the regulating resistance. For watt-hour or integrating wattmeters, of which the Thomson is a type, two circuits have to be supplied; firstly, the current or main circuit, and, secondly, the pressure or shunt circuit; but it is not necessary that these should be taken from the same source provided that coincidence of phase between the two sources of supply can be maintained. Again, with a varying number of meters in circuit it is advantageous that provision should be made for a varying E.M.F. on the testing leads The question of regulation is simplified while the cost of the load resistances is reduced very materially.

Mr. Voysey has met the conditions in a very simple and most satisfactory manner. Bearing in mind that the current taken from the mains is at a much higher pressure than is requisite for the purpose in view and that it is alternating, he has made use of a special transformer to reduce the pressure, and thus economise in the quantity of energy required. A Ferranti 10-unit transformer is supplied with the alternating current at a frequency of 100 periods per second, the primary being coupled across the outer conductors of the three-wire distributing mains, thus taking 200 volts on its terminals. The supply enters by the usual service leads, is then brought through a meter, primary fuses, and double pole switch, to the transformer. The supply meter—a Thomson watt-hour meter—is used to measure the quantity

of electrical energy taken by the laboratory. The appearance of the corner of the laboratory in which the transformer and switchboards is located is shown by fig. 1.

The corresponding bay to that occupied by the transformer and switchboard is fitted with teak panelling across the recess, to which wall meters can be fixed during trials. Between the bays is the regulating resistance, and on the side of the room the various measuring instruments.

The transformer has three secondary windings: one of these is of heavy strip to give the low pressure currents, the other two being of fine wire to supply the shunt coils of watt-hour meters.

(1) "Current" winding; maximum current, 500 ampères at anything between 2 to 20 volts by steps of 2 volts at a time.

(2) "Pressure" winding; 100 volts difference of potential, with maximum current of 2 ampères.

(3) "Pressure" winding; 90 to 110 volts difference of potential adjustable between these limits by steps of 2 volts; maximum current, 2 ampères.

The two "pressure" coils, (2) and (3), are coupled in series with one another; the "pressure" and "current" windings are quite distinct, and come to separate terminals. The capacity of the transformer is ample to meet any prospective requirements, as 300-ampère supply meters are the largest at present in use, and up to 500 ampères is obtainable. By the use of the two pressure windings in series, meters intended to measure a supply taken from the two outer conductors of the three-wire distributing system of the City can be tested. The largest meter likely to be employed will not exceed 500 ampères at 200 volts, and this is the extreme limit for which arrangements have been made to test up to.

The "pressure" winding of the transformer is brought up to a 13-point plug switch, so that the 2-volt steps are controlled by the position in which the plug is inserted. A second two-point plug switch enables the 100-volt pressure coil to be either included with the other or not, as may be required. Thus from 90 to 110 volts can be taken off, by intervals of 2 volts, or anything between 190 and 210 can be got by similar steps. This enables an adjustment of the watts on any integrating wattmeter to be made independently of the current; but the principal advantage of the arrangement is that a very close approximation to 100 or 200 volts can be made, irrespective of the slight variations which occur on the service lines. In practice this has been found to be very satisfactory.

The "current" coil of the transformer is even of more importance than the other windings. It is brought into use in any work which involves the calibration of ammeters, the testing of fuses, or the checking of supply meters. The sections are connected up to a commutator, which can carry the full current of 500 ampères. First the 10-volt section is brought to a double way switch, the five 2-volt sections go to the contact plates of a second switch having six points. The latter gives variations in the pressure of the meter circuit by steps of 2 volts at a time up to a maximum of 10 volts, by throwing over the former, and bringing back the level of the latter, 10 volts is again obtained, further increments being available by the five-point switch until when both are full over the maximum of 20 volts is on the circuit. The current passes out to the circuit through fuses and a heavy double pole switch. The connection of the transformer windings, and the arrangement of the circuit generally for meter testing, are indicated in fig. 2.

The current passes from the switchboard by a heavy conducting circuit of copper strip, which extends round two sides of the laboratory. The strip is 1½-inch by ⅓-inch, giving a sufficient cross-sectional area for the maximum load of 500 ampères. As the current is alternating, it is an important matter to secure a circuit of as small self-induction as possible; the other desirable condition that there should be no inductive action on instruments or apparatus being also met if this be secured. The manner in which Mr. Voysey has disposed his conductors is a very neat and effective one for the purpose. We believe that it was his intention, in the first place, to adopt a ring main of Ferranti concentric conductors similar in style to that in use at the Board of Trade Laboratory at Whitehall. The cost of so doing may have caused an alteration in the design, despite its advantages; but, in any case, the existing arrangement is quite as effective, and considering that the present equipment is not the final one, the copper strip main seems to meet all the demands put upon it.

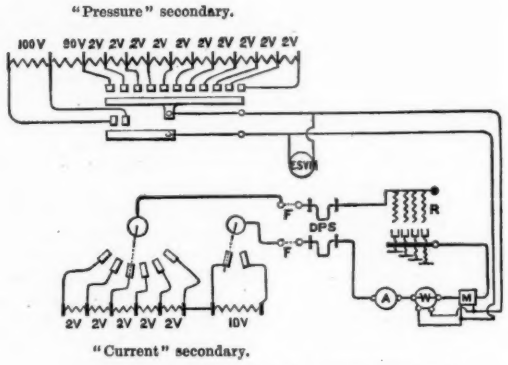


Fig. 2.—Connections of Meter Circuit.

A polished teak board, 4½ inches by 1½ inches, is supported by iron bolts fixed in the wall so that it hangs about 2 inches away from it. To this the copper strip is fastened by countersunk screws; one strip forming the lead is carried at the back of the teak, the other, which conventionally is spoken of as the return, being on the front. At intervals the strip on the face of the board is cut, and the ends provided with heavy butterfly-wing terminals, for the purpose of bridging the gap with brass short-circuiting bars, or for taking off heavy stranded cables to meters, &c. Above the measuring instruments pieces of strip are tied to the fixed strip close to the gaps, and come down to the wedge contact blocks which form the circuit ends for Kelvin balances. The smallest balance is coupled in circuit by a couple of flexible conductors leading up to an extra pair of terminals on the strip. By this device the instruments can be brought into circuit as required or short-circuited when not in use. The non-inductive regulating resistance is connected permanently in the same way, only in this instance there is no need to arrange for a short-circuit bar. At each end of the L-shaped teak frame the back strip is bent round in a semi-circle and brought to the front. The strip therefore connects up in series the transformer, measuring instruments, regulating resistance, and any meters or other apparatus joined across a gap. The insulation of the circuit is good, it is simple and convenient, and gives a low resistance conductor with almost negligible self induction. For the sake of appearance the strip where visible is painted bright blue, and the effect of the combination of the coloured conductor and its support of polished teak is very good. This may be a small matter, but it strikes the casual visitor more forcibly than some things of more technical importance. At any rate it avoids the many objections which could be urged against insulated conductors in casing, and serves to set off the whole.

The non-inductive regulating resistance is a well-made and substantial arrangement by which conductivities can be inserted in the circuit and adjusted to give exactly any current wanted. Messrs. S. Z. de Ferranti, Limited, are the makers, and it is similar in principle to a device made by them for the Corporation of Portsmouth. The resistance wires are of German silver, and are mounted vertically on the front of a heavy slate frame, being arranged concentrically round thick copper rods. There are five sets, each divided as below; the adjustment is made by circular mercury cups, which can be raised or lowered by a screw and handwheel so that any number of the five sets of resistances can be inserted in the circuit, and from one to ten of the individual conductors in each set. As either cup is screwed up the ends of the wires dip successively into the mercury, which puts them in parallel. The first set of resistances consists of ten wires, each carrying —provided that a suitable pressure is impressed on the circuit for the resistance included in it—$\frac{1}{10}$th of an ampère, the total conductivity allowing 1 ampère to flow. The second set gives 1 ampère for each of the nine wires comprised in it, or a total of 9 ampères. The third set has seven wires, each carrying 10 ampères, or a total of 70 ampères, and the fourth, also of seven wires, carries 20 ampères individually, or a total of 140 ampères. In the same way the fifth is of

seven wires each for 40 ampères, the whole giving 280 ampères. Therefore, when the five cups have all been raised to their highest position, the resistance carries:—

A.	10 wires	×	0·1 ampère each	=	1·0
B.	9	„	× 1·0	„ „	=	9·0
C.	7	„	× 10·0	„ „	=	70·0
D.	7	„	× 20·0	„ „	=	140·0
E.	7	„	× 40·0	„ „	=	280·0
						500·0

Practically the resistance will carry 500 ampères, and give an adjustment of about $\frac{1}{10}$th of an ampère. When, however, this current is flowing through a meter and balance, the change of resistance of the circuit due to the addition to, or subtraction from the circuit of one of the wires of the first set, will be so small that practically the current can then be adjusted to ·01 per cent., if such a close regulation be useful. It would be quite easy, if required, to provide means by which the observer at any of the balances could regulate the resistance by cords passing round the laboratory. The general appearance of the regulating resistance can be appreciated from the view given in fig. 1.

the wall between the sets of balances. One reads at the best part of its scale 100 volts and thereabouts, and the other double this pressure. The balances are mounted on slate shelves let into the wall, and supported by heavy wooden corbels; these are 2 feet 6 inches below the copper strip conductors, and 3 feet above the floor. They are, therefore, at a convenient height for long-continued observations by an observer seated before them. Space is available for further instruments if required. Fig. 3 is taken from a photograph of a portion of the laboratory in which the balances are located.

The test-table (fig. 4) at the back of the laboratory is arranged for insulation, copper resistance and capacity tests. On a sloping desk of polished teak are mounted a four-dial plug bridge with proportional arms, a standard high resistance of 250,000 ohms, a $\frac{1}{2}$-microfarad condenser of the circular form, with mica as the dielectric, and the reversing keys for galvanometer and battery. The bridge is placed at the centre of the upper edge of the table, with the condenser to the left and high resistance to the right. The latter is subdivided into five coils of 50,000 ohms each, each section coming up to pillar terminals. To the front is the battery

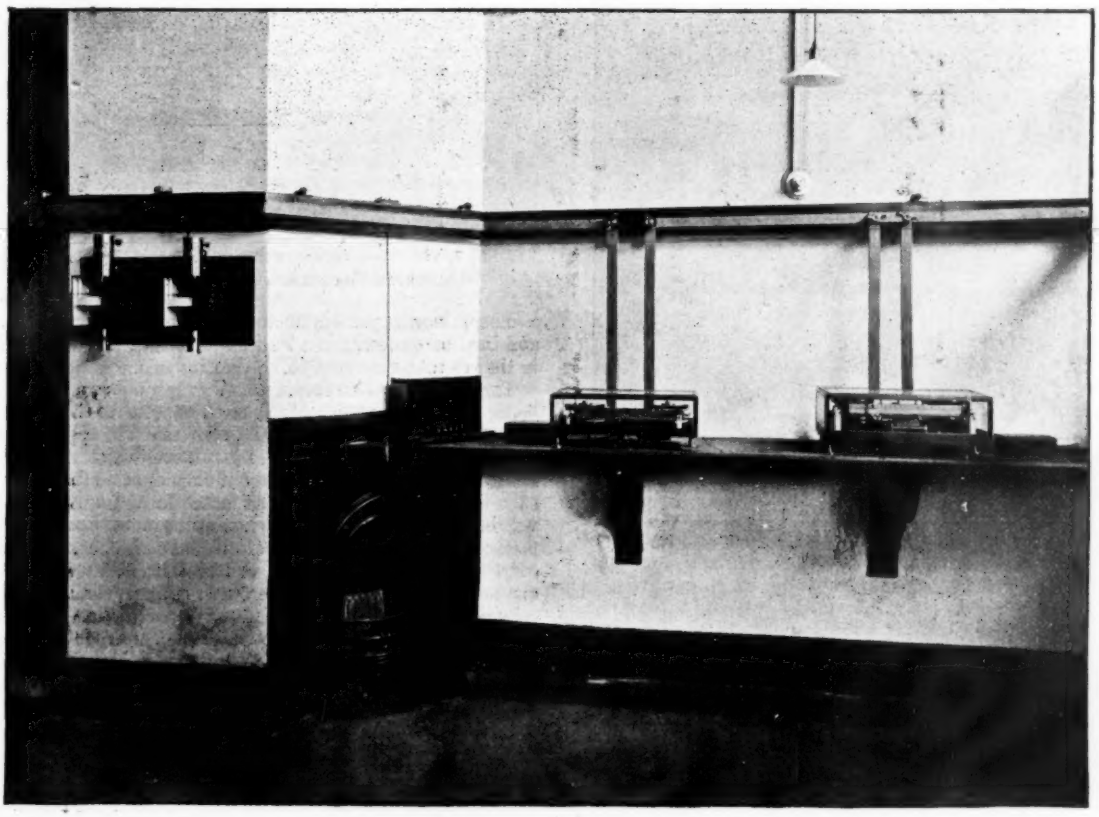


Fig. 3.—View of Measuring Instruments.

The current-measuring instruments are a series of Kelvin balances, including a deci-ampere, deka-ampère, and hekto-ampère balance. These give sufficient range for all the testing required, and being recognised standards, simplify the equipment. By using balances, the whole paraphernalia which would otherwise be necessary is done away with, and, as most measurements of current which profess to accuracy are taken by similar instruments, there is less likelihood of any question being raised as to instrumental errors. For meters of the Thomson type, the pressure has to be taken into account, and to get rid of all difficulties of lag a Kelvin watt balance, going up to 20 kilowatts, is used. This has the usual external resistance box in series with the pressure coil, and by taking the resistance of the movable coil with the resistance in series by the bridge, a correction for temperature is readily made.

A couple of Kelvin multicellular voltmeters are fastened to

key for reversing; this is fitted with locking cams of a pattern much superior to the old brass cams carried on pillars. On the same level is the plug reverser for the galvanometer high resistance winding, the circular shunt-box for the same, and a set of plug switches. The connections are all permanently wired, the plug switches being coupled up, so that either insulation, capacity, or copper resistance tests can be taken by merely plugging up the instruments, without altering any of the wiring. The low resistance winding of the galvanometer is connected to a short circuit key, and thence to the bridge. Capacity or insulation tests are taken with the high resistance coils, and conductivity or copper resistance with the low resistance winding. The plug reverser acts as a short circuit key to the galvanometer when taking insulation or capacity. A battery of 100 dry cells, the smallest size of the Obach, is provided for insulation, and four large cells for copper resistance tests. By means of the battery

switch any number of the small cells can be brought into circuit, or the four large cells, as may be required. The operations permanently arranged for are: bridge, insulation constant, insulation test, capacity constant, capacity test. From the right hand block of the three-way plug switch, giving "constant" or "test," a lead is taken to the cable or

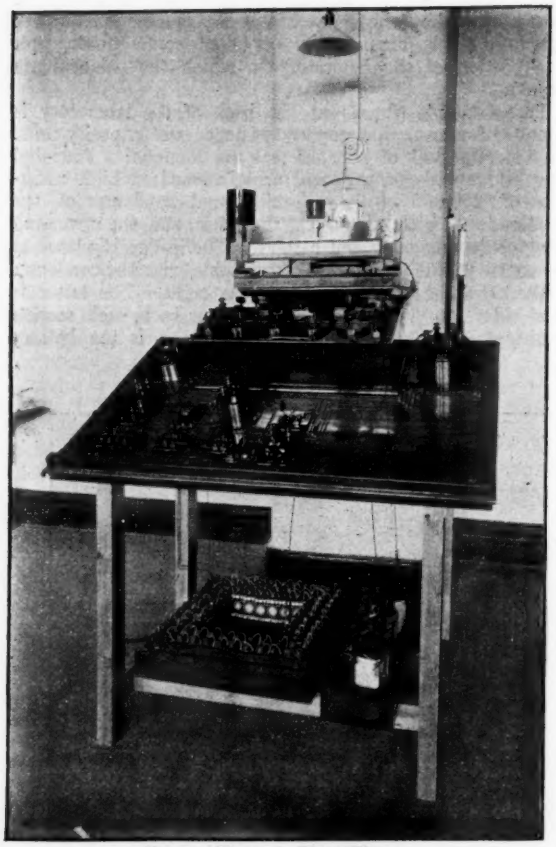
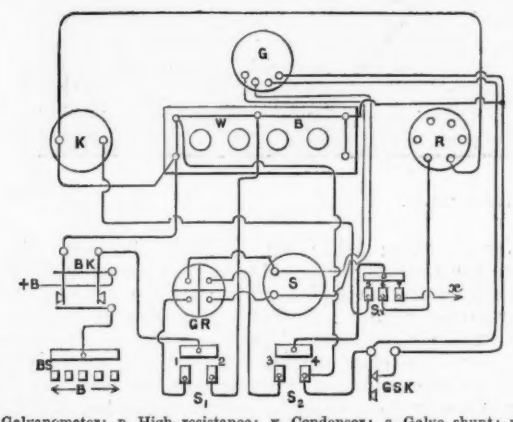


Fig. 4.—View of Test Table.

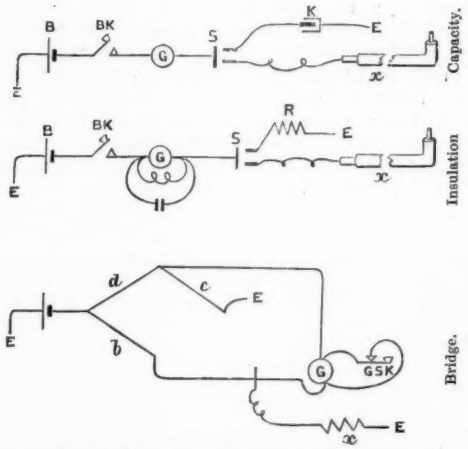
meter to be examined. To enable comparisons of E.M.F. to be readily effected, a pair of Carhart-Clark cells in a case, fitted with thermometer, are provided. The connections of the various instruments are indicated by fig. 5, the arrangements for each test being shown by the diagrams given in figs. 6 to 8.



G, Galvanometer; R, High resistance; K, Condenser; S, Galvo. shunt; W B, Wheatstone bridge; B S, Battery switch; B K, Battery key; G R, Galvo. reverser; G S K, Galvo. short-circuit key; S_1, Plug switch; S_2, Plug switch; S_3, Plug switch; x, Test lead; B + and B, Battery.

Fig. 5.—Connections of Test Table.

The galvanometer is a square case instrument by Messrs. Nalder Brothers, and is provided with the usual controlling magnet and tangent adjusting screw. The terminals are carried by the ebonite base. The galvanometer rests on the base of a Jacob transparent scale, the scale being supported at the front edge on a level with the observer's eye, and just over the back of the test table. For the present, the Jacob's scale is used with an oil lamp, the spot of light being crossed by the dark hair line thrown by a fibre stretched across the beam before reaching the mirror. This combination is an excellent one, and Mr. Voysey has made a good choice in going to Messrs. Siemens Brothers for their speciality. The galvanometer and scale are mounted on a wood base borne by brackets let into a brick pier forming part of the building. The pier, however, seems to have been specially designed to carry a galvanometer; at least, it comes in very well for the purpose.



Capacity test, constant, plug 1, 3 and 5; Test, plug 1, 3 and 7; Insulation test, constant, plug 1, 3 and 6; Test, plug 1, 3 and 7; Copper resistance, plug 2, 4 and 7.

Figs. 6, 7, and 8.—Connections for Capacity, Insulation, and Copper Resistance Tests Respectively.

The minor apparatus include a standard thermometer, a standard barometer, and a Fuller's slide rule. A chronometer is used to take the speeds of revolution of meter armatures.

The laboratory also forms Mr. Voysey's office, a desk, &c., being placed on the side of the room opposite to the balances. From our description, it will be seen that the apparatus includes the smallest number of instruments which could satisfactorily be held to meet the requirements of a laboratory of such importance. No doubt an inspectional ammeter or two will be added later. We will not attempt to deal with the methods by which meters are tested at this time, it is sufficient to say that rate tests at different loads, together with one test for quantity passed through, is in general the procedure adopted. The whole of the apparatus has been supplied by the different firms, Messrs. S. Z. de Ferranti, Limited; Messrs. Nalder Brothers & Co., and Mr. James White, to Mr. Voysey's specification, and has been erected under his supervision.

OZONE AND NITROUS COMPOUNDS.

By E. ANDREOLI.

We cannot attach any importance to the statement made before the Académie des Sciences by Saint Edme and Lhote, that the ozone produced by the condensation spark in Beane's apparatus contained "no trace of nitrous compounds."

Hautefeuille and Chappuis have ascertained: first, that there is more ozone formed in nitrogen mixed with oxygen than in oxygen itself; second, that there is more ozone produced in a mixture of oxygen and hydrogen than in a mixture of oxygen and nitrogen.

It would be a mistake to believe that because oxygen is transformed to a certain extent into ozone, by the silent electric discharge, nitrogen will be transformed in the same proportion into a nitrous compound. Ozonised oxygen passed through water does not form peroxide of hydrogen; hydrogen and oxygen do not form any combination under the influence of the electric effluvia.

The quantity of ozone may be increased by adding to oxygen another gas, but it does not follow, and nothing indicates, that the two gases will form on one side, ozone, and on the other one a compound such as $N_2 O_5$.

The experiments made in 1877 by Berthelot showed that ozone does not combine with nitrogen at ordinary temperature in the presence of alkalies, that the production of ozone is not correlative to the formation of nitrous compounds, and that it does not seem that the presence of ozone causes an oxidation of nitrogen. The conclusion he came to was that the formation of ozone and of nitrous compounds takes place under the influence of powerful effluvia and in very different proportions, and that with less tension, ozone is rapidly formed in the air, but that the proportion of nitrous compounds is then hardly appreciable.

There is no apparent modification in a mixture of ozone and chlorine submitted to the electric effluvia, but if traces of nitrogen are added to it there is a whitish deposit formed on the ozonising tube.

Thénard has produced nitrate of ammonia by combining water with nitrogen by means of the effluvia, but it took him many hours to absorb 5 cc. of nitrogen, and in order to do it he was obliged to pass steam through the tube.

We have no information whatever as to the action of the silent electric discharge on the nitrogen and the oxygen of the atmosphere.

When a mixture of nitrogen and hydrogen is submitted to the action of the effluvia, a little ammonia is formed: then the reaction stops and recommences if sulphuric acid is added, but for a little while only; and if water is added instead of sulphuric acid the reaction goes on.

According to Dr. Houzeau, in the electrification of air by the silent discharge, a mixture of ozone and a small quantity of nitrous compounds is obtained which can be separated by means of iced water.

I may say of these nitrous compounds in ozone what Cahours said of the nitric and hyponitric acids, which he mentioned as being the only nitrous compounds which can possibly exist in the atmosphere, "if nitrous compounds can exist, they are in so small a proportion as to be hardly appreciable."

Boillot used to destroy what he called the hypothetic compounds of nitrogen by passing the ozonised air through a solution of caustic potash. A very simple way to avoid the influence of the nitrogenous compounds is to ozonise oxygen instead of atmospheric air.

The production of nitrous compounds has been greatly, and without any ground, exaggerated. In spite of the most careful researches in the electrical and medical publications, I have been unable to find any experiments showing, either the percentage of nitrous compounds or their noxious influence on persons who had been breathing the ozonised air.

I quite believe that the ozone which years ago was formed by means of phosphorus, or by the electric spark of an influence machine, or of the Ruhmkorff coil, was thoroughly contaminated with nitrous products.

If small ozonisers, real toys, working with two bichromate cells and a small induction coil, were capable of forming an appreciable amount of nitrous compounds, there would be no difficulty to produce nitrous compounds, nitrates, or nitric acid by means of special and powerful ozone generators.

My own experience tells me that there is no danger in ozonised atmospheric air, and we can take it for granted that if, after so many years, the medical profession has not been able to formulate an interdict against the sanitary and therapeutic applications of ozone, it must be because ozone, which Frémy used to call *one of the most beautiful questions which chemistry may have to treat*, is not only safe but healthful and beneficial.

REVIEWS.

Electro-magnetic Theory, Vol. I. By Oliver Heaviside. The *Electrician* Printing and Publishing Company, Limited.

We did not review this book when it first came out because we thought every electrician would read it at once and judge for himself. We met one, however, who has not done so yet, and have heard of more, and it is to induce him to do so at once that we now write this somewhat tardy review.

The basis of this first volume is action through medium, analogy of the interlinked electric and magnetic circuits, and the transference of energy through the medium. Mr. Heaviside thus gets rid of the action at a distance, mathematical treatment of the subject, and deals rather with magnetic and electric forces than with their integrals, the corresponding potentials. Three fairly long reviews have already appeared in some of our contemporaries by Profs. Fitzgerald and Minchin, and Mr. Swinburne respectively. One review dealt largely with Mr. Heaviside's treatment of waves and distortion; the remaining two discussed among other things, his views as to the elimination of 4π and the advantages of his vector as opposed to quaternion analysis. Mr. Heaviside's book provides inexhaustible texts for sermons, so we will, as far as possible, avoid going over parts already discussed, and will rather deal with other points, in fact, rather with minor and disconnected points. Mr. Heaviside's work in bringing vector methods into use is bearing good fruit both here and in Germany. Hamilton's "Elements" has been out of print for a long time, and a German translation has alone been available for the last 12 years. Quaternions are puzzling, and so is German, if one's knowledge of the language is imperfect, and the depressing influence of the combination is hardly counteracted by the delight of buying a second-hand copy cheap. Föppl has lately brought out an important introduction to Maxwell's "Theory of Electricity," in which he practically adopts Heaviside's methods. We have not read this book, however, nor even reviewed it. Lorenz and others are adopting the notation and nomenclature, so that the sooner vector methods become generally understood the better. It is strange, however, that vector analysis should flourish rather in Germany than in this country.

Mr. Heaviside's views of the practical man are amusing, and there is a good deal between the lines. In discussing the force of a conductor in a field, for instance, he says "it is what is so extensively made use of by engineers in their dynamos, motors, and things of that sort. It is probable, I think, that in grinding away at the ether they also stir it about a good deal, though not fast enough to produce sensible disturbances due to etherial displacement." This is characteristic of his views of what he calls "practicians." It is a common idea among the more narrowminded that practical men merely apply the ideas of purely scientific men and thus belong to a lower order. If scientific men work with the view of the practical application of the results of their trouble, they merely produce raw material which is of little value till some practical man who possesses the requisite ability works it up. The engineer is then really higher than the producer of raw material. If the scientific man works not only without being able to make his work useful himself, but without any idea of its being useful, he ought to rank still lower. We do not rank the sperm-whale above the man who collects ambergris and uses it in perfumery. No doubt the sperm whale has a sublime contempt for human beings in general, and, perhaps, even for Mr. Heaviside. Mr. Heaviside is very bitter about the man who does not believe in mathematics. We believe this man's existence is a myth. We have never seen a specimen. On the other hand, we have noticed that most people have the greatest respect not only for mathematics as a useful tool when properly applied, but for bogus mathematics. Nearly the whole of the fashionable methods of discussing alternating currents are bogus mathematics, wrong data being assumed to make the calculations simple. Any young fellow with a smattering of mathematics can write articles about K, L, and R without any idea of what he is discussing. No addition to the knowledge of alternating currents leading to any practical development has yet been made by people who string calculations together about harmonically varying quantities. The bogus mathematician does not even read the work of other bogus mathematicians, so that the same problem with the same impossible conditions appears treated in the same way time after time. For instance, the rise of pressure in the Deptford mains, or "Electrical Resonance" as it is wrongly called, is discussed anew as a phenomenon depending on L R and K every month or two. As already stated, this sort

of work requires a small knowledge of mathematics, and a large ignorance of facts, and as Mr. Heaviside would say "Beetles could do that." Yet the bogus mathematician is universally regarded as a great authority on alternating current work. Our regret is that people hold the real mathematician in such high esteem that they respect even the spurious imitation. It is doubtful, however, whether even the genuine mathematician does not receive more honour than is his due. Apart from original discovery, mathematics requires little more than very close attention in reading, and the faculty of forming mental pictures, a faculty possessed by every chess player who looks forward several moves. Some people hold that women's successes at Cambridge only go to show that mathematics does not require a high type of brain after all.

It is generally supposed that electricians, especially the benighted practical kind, are so accustomed to regarding the conductors as "carrying the current," and as conveying the energy from one place to another, that it is impossible for them to get a clear idea of what is now the more orthodox treatment. To such people, Mr. Heaviside's must, of course, remain a sealed book. It is hardly likely, however, that anyone who could form any mental ideas of what went on according to old notions could not equally easily regard it from the newer standpoint. We believe the true difficulty lies much deeper. The older method really involves the "hydraulic analogy," and while people talk of electricity they think of water, when they think of anything at all, and water and pipes are quite familiar. The new electrician, however, deals with ether and energy. When you ask what ether is, you are told that it is matter with a great many of the properties of matter removed. You therefore think of matter. If you are told to think of calves'-foot jelly, which has no weight, no taste, no capacity for heat, and no boundaries, you still think of calves'-foot jelly. All the attributes of calves'-foot jelly are removed, but no other concept has taken its place, and though all the distinctive qualities of calves'-foot jelly are negatived, you still think of calves'-foot jelly and nothing else. In the case of the water analogy, the electrician never tried to picture electricity mentally as water with most of its distinctive properties removed; he merely gave up all attempts to think of electricity at all, knowing that if he thought of water and pipes and so on, he would be led to results which would be applicable in electrical cases. The modern electrician does not take this line at all. He does not say "Think of jelly and with due precautions you will get results agreeing with those in the case of the unthinkable ether." On the contrary, he insists that ether is a thing. Of course, such a discussion as this opens a very large question, and a question which is not suited to these columns. It is quite open to anyone to say that a word which covers no concept at all, and conveys no idea at all, is only a sound —mere gibberish; but a word which pretends to convey an idea, but really conveys a totally different idea is worse, it is misleading nonsense. This is the case with such a word as ether. To many minds this use of a term which really conveys one idea while it professes to convey another, is a fatal objection to all theology and religion. We do not wish to say anything that may offend any reader, nor do we wish to touch such a question lightly here. We may, perhaps, be allowed, merely as an example, to instance the word soul. If you ask the meaning of this term you find it denotes a person after all his attributes have been removed verbally, but the concept remains in spite of the verbal stripping, still a man. If you remove all the attributes of a dog, however, nothing remains, while in the case of a human being the remainder is infinitely the most important part. Other and more important instances in religion will occur to any one who thinks, without being referred to specifically. It is a very curious thing that one and the same kind of unreasonableness should play such an important part in the very foundations of religion, and of some branches of the most advanced science. Turning to the question of energy we may take its movement as a good example. We are accustomed to the indestructibility of matter, or in other words we have so often seen that it is not annihilated, that we take it for granted it is never annihilated. Therefore if it disappears in one place, and appears somewhere else, it must move through the intervening space. We also find that energy is indestructible. It is therefore argued that energy also moves through the intervening space. Energy is in fact also matter with the attributes of matter verbally removed. It is a good thing to put statements into the simple form of syllogisms as found in logic books, but seldom elsewhere. The major premiss is then All matter exists continuously; the minor premiss, Matter A, disappears at B, and appears at C, the conclusion Therefore the matter, A, exists continuously. Take the case of energy, the major premiss is as before All matter exists continuously, the minor, Energy A, disappears at B, and appears at C, and the conclusion Therefore the energy A exists continuously, which of course involves its movement across the intervening space. The second syllogism is obviously fallacious, and the reason why it has stood is that the energy, A, is thought of as matter, and thus comes under the major premiss in spite of its materialness being verbally disclaimed. If the modern school were aware of these difficulties they would advance as working hypothesis what they now put forward as theories. The distinction between a working hypothesis and a theory is about as wide as it can be, but few people seem to recognise the difference. We have not Poynting's paper before us, but if we remember right he pointed out the danger of fallacious reasoning about the movement of energy. If the modern electrician gave up talking of inconceivables as if they were conceivable, and had recourse to working hypotheses instead of theories, we believe the more enlightened and simpler treatment of action through the medium would become popular at once, and the hydraulic analogy would disappear.

There is some obscurity in section 88. At the end of the first paragraph it is surely the surface integral of the curl of c_0 which is equal to v. If the boundary of the surfaces, s, s_1, s_2, is a line the curl there is infinite. This is a small slip at most, but the whole question of cyclosis in magnetism is involved. Imagine the surfaces to be magnetic shells. The orthodox method of finding the magnetic potential is to take the line integral round a path starting anywhere and coming back to the point cutting the surface once. But in magnetism the line integral is always taken not through the surface, but through a specially arranged hole in it, so that it comes out zero. If the magnetic shell is replaced by an equivalent current at its boundary, the hole would have to be replaced by a little local circuit with an equal current in the opposite direction. By this convention the magnetic shell is replaced by an electric current at its boundary only as far as the space outside its substance is concerned. We do not see the reason for this, and it is to be hoped Mr. Heaviside may be induced to put the matter more clearly some day.

At first sight it looks as though taking the true integral through the shell itself instead of through a hole in it would lead to perpetual motion, as a unit pole would go round and round for ever if it were given the chance. This does not follow however. Replace the shell by the equivalent bounding current, and take, not an isolated unit pole, but a long flexible magnet. Imagine the current to be in a perfect conductor so that there is no external electrical pressure, or, as Mr. Heaviside would say, no voltage. The current-carrying conductor represents some energy, as it has a field, or, in the language of practicians, it embraces lines of induction. Their number is invariable. Now, let one end of the long flexible magnet loose in the neighbourhood. It will interlink the magnet through and through the circuit, weakening the external field and reducing the current till finally there is no external field due to the current and no current, the invariable number of lines of induction being in the convolutions of the flexible magnet. Work would be done in moving the end of the magnet, and this takes up the energy of the system. The final result is not anything like perpetual motion; merely that the energy of the system has been used up in moving the end of the magnet, and the current has ceased and the only remaining energy is that of the flexible magnet itself which existed before. In accordance with this way of treating the subject a magnet may be treated on the hypothesis that there is a current in a perfectly conducting circuit round each particle, and the line integral can be taken through the particles composing a magnet instead of dodging between them.

Take now the case of an electric shell, or a sheet whose sides are positively and negatively electrified. Replace it by an equivalent magnetic current in a perfect magnetic conductor. This idea is a little outside one's ordinary work, but to get a clear notion any point may be assumed; the magnetic conductor may be, for instance, a ring and the point the centre. Lines of induction may be pictured as starting as points at the centre and growing into circles which con-

tinuously widen till they coincide with the magnetic conductor. The result would be an electrical displacement whose surface integral over all surfaces bounded by the ring would be the same; and there is, of course, energy in the system. Imagine a circuit of copper wire interlinked with the ring. There is a voltage in it, and a current, which means power. As the surface integral of the displacement remains the same, the diminution of the surface integral of the displacement in the dielectric is equal to the current. Finally, the energy of the system is converted into heat in the copper, and the magnetic current dies down. The stress in the medium is gone, its energy having been wasted in the copper. It might be thought that if the magnetic conductor had been storing up lines at the rate of 10^8 per second per volt in the copper circuit it would be pretty well saturated after a year or two, and that the closed magnet with all this accumulation of induction would represent stored energy. A closed magnet does not, however; though it must be noted that it might take energy to break it, and it would have an astonishing tensile strength if lapped round nicely with a perfect electrical conductor.

These methods lead to electric and magnetic shells where the line integral can be taken through the shells instead of through holes in them, and if desired the dielectric may be treated as if each particle had a magnetic current round it in a perfect magnetic conductor. It does not matter where the surfaces are, the boundaries are alone important. It thus makes no difference where the lines of induction in the second case come from as long as they are always closed on themselves, and finally coincide with the ring.

Mr. Heaviside is, as is well known, a very humorous writer, but most of his humour is unfitted for quotation, depending on the context. There is a curious variety of refreshing cantankerousness running through his work. Sometimes we cannot see his point, as, for instance, "also pot means 'potential,' or 'the potential of,' and has no more to do with kettle than the trigonometrical sin has to do with the unmentionable one. It seems unnecessary to say so, but one cannot be too particular." Perhaps the curve of sines and L and K method of dealing with alternating currents is the trigonometrical sin.

Mr. Heaviside's nomenclature is gradually coming into use. Personally, we dislike some of his terms, and other people will doubtless dislike others. Still, his system is fairly complete and systematic, and in such cases it is best to follow a leading authority and to sink personal fads. Some of his small alterations are very neat. Shin, for instance, is an improvement on hsin, if one happens not to be a horse. Most students will agree with us in liking "vex" as a name for ∇.

We hope these stray notes will entice those of our readers who have not yet done so to peruse this book. We shall.

Motive Powers and their Practical Selection. By Reginald Bolton. London and New York: Longmans, Green & Co., 1895. 6s. 6d.

This is one of a numerous class of books which owes its contents to the price lists and catalogues of the manufacturing engineer; but to do the author justice, we would say that it is better put together than most of such books are, and it is devoid of the padding of illustrations, for there is not one illustration in it, while, at the same time, the excerpts have been made with very fair judgment. But we can hardly think it necessary to include tables of weights of cast-iron pipes, sheet metals, and similar information which everyone has at hand in the regular pocket books, unless it is to be supposed that those who will use this book will not possess an ordinary engineer's pocket book, scarcely a likely contingency. Infinitely better is the comparative table of powers which gives the ratio of 33,000 foot pounds per minute to the power of men at cranks, oxen, horses, a 16 feet windmill, a waterfall, coal in various classes of engine, gas and petroleum. As to the definition of horse-power, did not James Watt determine a horse-power as equal to 22,000 foot pounds per minute, and not as 33,000 as stated by the author. We believe the latter figure was simply arrived at by an addition of 50 per cent. to the experimental figures for the sake of margin, so that buyers of Watt's engines should not have cause to grumble at lack of power. Watt was a cautious and canny Scot, who had a very keen eye to the main chance, and was by no means civil to the first and best engineer of the time, poor Trevithick, and we have no doubt he added 50 per cent, to the price as well as to the size of his nominal horse-power. Peace be to his ashes, however, for he knew the value of a hot cylinder and we all seem to be finding it out again to-day, though some of us when apprentices, and not hampered by thoughts of cost or balance-sheets, knew it in our youth.

Perhaps the most novel feature of Mr. Bolton's book is his inclusion of prices in sterling and dollars for the various motive powers he describes, and adjuncts, and so far as can be seen in glancing through some of these items, they appear to be fair guides. On all questions of motive power by windmills, turbines, or steam engines, of fuels, solid, liquid, and gaseous, the author, who has, perhaps, found his chief experience in general engineering, has not selected and strung together his materials in a bad way, and we rather like his chapters on fuels, on the steam engine, and on condensation. He might have added a word of caution as to the desirableness of occasionally boring out the vertical pipes of economisers, which gradually make up with deposit and lose much of their efficiency thereby. There is sound sense in the author's condemnation of such terms as "Colonial," "Continental" to fire-boxes of boilers, terms which appear to be simply pegs on which to hang an excuse for an "extra" and which ought to be buried with the defunct nominal horse that still pollutes the engineering air. If, however, our author had been up to date in his information on circulation in Lancashire boilers, he would have known better than credit the cross tube with giving a better circulation. He evidently requires to study the special tests made a year or two ago on this question to find that these tubes are useless in that respect and of little good as heating surfaces, while they are great smoke causers and utterly useless as strengtheners of the flue, for they cannot be put in the furnace, which is the weakest part. It is in little things like this that the author's work as a collater rather than as an original writer shows up. We note also that he does not give the best formula for flue tube strengths. The one he gives is Board of Trade, and he does not give that correctly, for he omits the bracket in the denominator $D \times (L + 1)$ in case of both the steel and the iron furnace, and he omits to credit the rule to the Board of Trade. Indeed, there are few references throughout the book to the sources of information, and we are thus left to such faith as may be in us as to the gospel according to Bolton, which is by no means just the gospel of salvation on all points. Did he tell us this is Watt's, and that is Fairbairn's, and the other is Bolton's, or any other fellow's formula we should know just how we stood, but we get set down straight a collapsing formula on the authority of Bolton: it turns out to be Board of Trade, and we had as lief trust Bolton, as the old red tape board in which our faith is not great so far as the Board's knowledge of boilers for land purposes is concerned. Still, we should have liked the formula given correctly. We prefer Longridge's or similar rules.

But we have most serious fault to find with the chapter on electricity. In the first place we are told that electricity is not a prime motive power. So far as the word prime is applicable to the heat engine in any form, electricity, when derived from a primary battery, *is* a prime mover, for such electricity is the result of decomposition, generally of zinc, exactly as heat in the furnace of the steam boiler arises from a similar chemical disintegration of carbon fuel. It is merely a difference in fuel, but zinc is a costly fuel and less used for heavy work than carbon. Still, electricity so generated is the prime mover in an enormous industry, to wit telegraphy, &c. Let us give next the definition of a secondary battery, the worst we have ever seen:—Speaking of the cells he says: "*They are boxes containing alternate frames or plates of various compositions, chiefly based on lead, which, being immersed in dilute sulphuric acid, one set are decomposed by the action of the electric current and deposited upon the other.*" A lay brother might well read this to mean that the cells are boxes usually placed on leaden pedestals, otherwise on firebrick or other convenient substance. Being filled with acid these boxes become very rotten, and one-half of them rot so quickly that they leak and are then stood upon the remainder, into which we presume they drip. But, seriously, the author's understanding of the action of secondary batteries is lamentably at fault, and would disgrace an elementary science student.

Let us quote again: "*On forming a reverse circuit of outlet from these plates a lesser reverse action takes place, the deposited metal going back to its original plate, giving out a feeble current in so doing, until the original equilibrium is established.*"

Could anything be more simple if it were only true?

Then, again, "*the standard ohm is the resistance due to a copper wire* $\frac{1}{16}$*th inch diameter* × 129 *yards long.*" Has Mr. Bolton ever heard of a column of mercury 106·3 centimetres long, and of one square millimetre section at a temperature of 0° C?

Speaking of danger arising from electricity: "*Shocks of any kind are unknown in properly insulated arrangements.*" How about static shocks, Mr. Bolton?

Further, we are told "fire can only arise from leakage of the electric current." There is no necessity for any leakage to occur to cause a fire, a red-hot conductor is ample. A table of loss of voltage per 100 yards of cable is given, and nothing is said of its weight. A cable may be big enough to lose practically no voltage per 100 yards, or small enough to lose it nearly all.

Dealing with accumulators these are spoken of as "standard;" we were unaware that any accumulator had yet been accepted as standard, while there are several good ones in the market.

The word ampère is omitted in a statement of output of the accumulator, and this can only be found out by comparing a given sequence of figures with a table on the next page.

The author should have obtained the services of some electrical friend in the preparation of this chapter, which had otherwise been better entirely omitted, for it puts a bad ending to an otherwise fairly good book. As though thrown on the wrong tack by the electrical chapter, the final chapter on shafting includes a serious error in the formula for shaft diameters, which are shown to vary with the square root of the moment of torsion in place of the cube root, an error at variance with a statement immediately foregoing in which correct proportions are enunciated, but how is the reader for whom the book is chiefly intended to know which to select.

On the whole, the practising engineer does not need this book, and authors need to be very careful when compiling for the mere user whose ability to detect errors and weak points is limited.

We quite fail to understand the figures given in the table on page 26. If we are not much mistaken an error of about 40 per cent. runs through every item in the table, the quantities given being under two-thirds what we ourselves calculate. For instance, 1,000 gallons raised 30 feet per hour is given as equal to 3,120 foot pounds per minute. We make it 5,000, and so right through.

CORRESPONDENCE.

To English Wire Makers.

Will you permit me to point out that the statement made by the President of the National Telephone Company at the Telephone Inquiry that the company was obliged to go to Germany to get the best wire, does not refer to insulated wire. I believe the company gets all its supplies of insulated wire and cable in England, and a wide experience enables me to assert that English manufacturers of insulated wire are still a long way ahead of their foreign competitors in the quality of their manufactures, and in most kinds of insulation they can sell as cheaply as the foreigner where the quality of material to be supplied, conditions of delivery, &c., are equal.

G. Sutton.

June 1st, 1895. (*W. T. Henley's Telegraph Works Co., Ltd.*)

We have read with much surprise the remarks made by Mr. Forbes at the recent Telephone Inquiry, to which you draw the attention of English wire makers in your issue of the 31st ult., respecting the alleged superiority of German wire over that made in this country.

If Mr. Forbes refers to copper wire, as we imagine is the case, we think he will find he has been in some way very much misled, and we unhesitatingly challenge him to produce any such wire made by any manufacturer in Germany, or, in fact, in any part of the world, superior for electric conductivity and mechanical tests to that regularly made in our Oakamoor works. We should only stipulate that the specific qualities required be stated beforehand.

Thos. Bolton & Sons.

June 3rd, 1895.

BUSINESS NOTICES, &c.

Ready.—The Universal Electrical Directory. This directory for 1895, which is on sale at 22, Paternoster Row, by Messrs. H. Alabaster, Gatehouse & Co., contains a total of 20,958 distinct names of individuals and firms, being 2,500 more than were contained in the previous edition, and about 8,000 more than any other electrical directory published. In addition to the incorporation of new names, all have been carefully revised, much financial information has been added, the telegraphic addresses and local telephone numbers are given, and the total of pages in the work is increased by 80, making in all about 866 pages entirely of directory matter. Price 4s.

Agency.—Messrs. Francis & Spilsbury, electrical agents and suppliers, of Mansion House Chambers, have taken up an agency for Mr. A. P. Lundberg, and keep a stock of his manufactures.

Appointment Open.—An assistant gas and electricity manager is wanted by a gas company in West Australia. Salary £250 per annum, with house, light, and fuel. Applications, giving all particulars, testimonials, &c., to Box 61, P.O., Oldham.

Bankruptcy Proceedings.—At the Liverpool Bankruptcy Court, last week, L. J. Barnacle, formerly carrying on business as Hall & Co., came up for his adjourned examination. The examination was closed.

British Electro-Chemical Agency, Limited.—A petition which was presented on November 1st, 1894, for confirming a resolution reducing the capital of the company from £75,000 divided into 7,500 shares of £10 each, to £50,000 divided into 2,500 vendors' shares of £10 each and 5,000 ordinary shares of £5 each is directed to be heard before Mr. Justice Kekewich on Saturday, June 15th, 1895.

Business Announcement.—A circular signed "Andrew Pears" states that from June 1st the works of the Thames Electric and Steam Launch Company, of Twickenham, are under new management, and all communications should be addressed to the company and not to employés.

Business for Sale.—The business of Messrs. D. & G. Graham, electrical engineers, gas fitters, ironmongers, &c., of Glasgow, is offered for sale. To-day is the last day for sending in offers to Mr. J. A. Macleod, 101, St. Vincent Street, Glasgow.

Dissolution of Partnership.—The *London Gazette* contains notification that the partnership heretofore subsisting between J. A. Lea, F. J. Lea, and A. H. Lea, carrying on business as electrical and general engineers and art and general metal workers at Pengwerne Works, Chester Street, and the Square, both in Shrewsbury, under the style of Lea, Sons & Co., has been dissolved by mutual consent so far as regards the said A. H. Lea, the junior partner of the said firm, who retires therefrom. All debts due to or owing by the said late firm will be received and paid by J. A. Lea and F. J. Lea, who will continue the business under the style of Lea, Son & Co.

Electrical Engineering in Austria.—It is stated that the Hungarian Credit Bank is forming a company with a capital of 5,000,000 gulden for the financing of electrical undertakings.

Hermite Sanitation Process.—We understand that a complete plant on this system has recently been fitted on board the Compagnie Transatlantique's steamer, *Paraguay*, and a complete set is also being fitted on one of the cruisers building for the Brazilian Government.

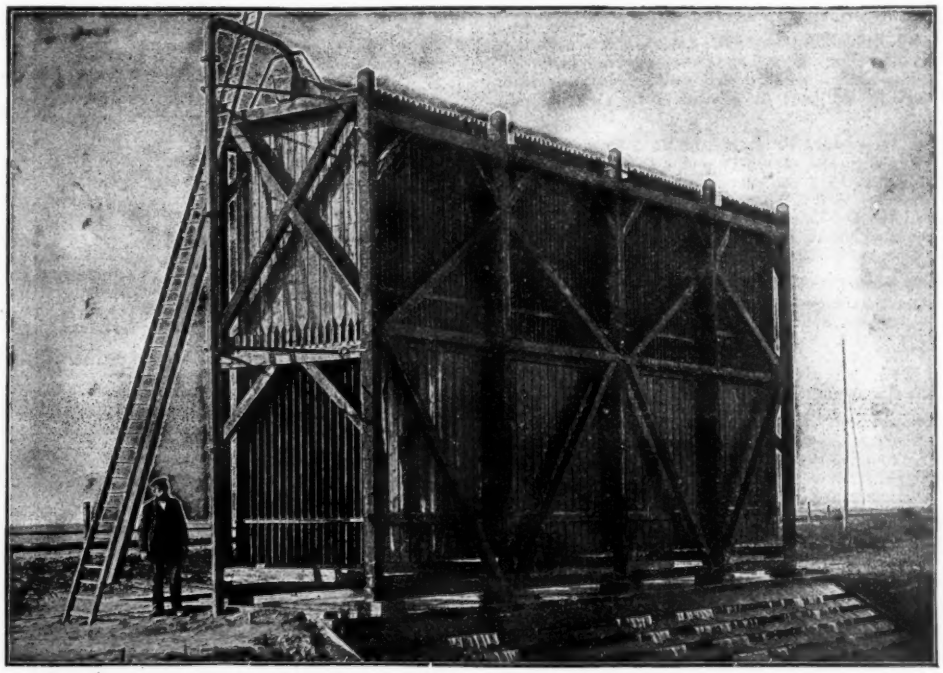
Price List.—A very neat price list (1895) of sluice valves and various brass, iron, and gun-metal steam fittings, has been sent to us by the Lunken Valve Company of Great Dover Street, who are the general European agents for the Lunkenheimer Company, of Cincinnati. The list is well illustrated, priced and particularised.

Publication Received.—"A First Book of Electricity and Magnetism," by W. Perren Maycock. Messrs. Whittaker & Co., London. Price 2s. 6d.

The Tumler Switch Case Settled.—The action brought by the General Electric Company against W. McGeoch & Co., and others, for infringements of the Tumler switch patent has been settled on terms satisfactory to each party in preference to taking the matter into Court. W. McGeoch & Co., Verity & Sons, and Evered & Co., have taken licenses from the General Electric Company under which they will continue to manufacture and sell Tumler switches with the heel piece as before.

The Medical Electrical Institute, Limited.—From the observations of the Senior Official Receiver (Mr. C. J. Stewart) issued under a winding up order recently made in this case it appears that the company was registered on October 16th, 1894, and was formed for the purpose of acquiring the business hitherto carried on by the Medical Battery Company, Limited, for the sale of medical and electrical appliances, &c. An order of Court had been made on November 22nd, 1893, for the winding up of the old company; meetings were subsequently held of the creditors and shareholders of that company, which unanimously approved of a scheme of reconstruction, and on July 25th, 1894, the Court sanctioned the scheme, of which the Medical Electrical Institute is the outcome. The registered capital of the new company was £75,000, of which £50,000 ordinary shares were to be issued as fully paid to the shareholders of the old company, while £25,000 preference shares, or such portion of them as might be required, were to be issued to the unsecured creditors of the old company, in accordance with the admission of the proof of such creditors by the Official Receiver. On October 17th, 1894, Mr. C. B. Harness, who had previously been the managing director of the old company, was appointed manager of the new company at a salary of £600 a year. It subsequently became apparent that the new company was not in a position to carry out the terms of the scheme of reconstruction, and in January last Mr. Ernest Hart was appointed by the Court receiver for debenture-holders, and is understood to have been since that date in possession of all the company's assets. Upon the commencement of business by the new company advertisements seem to have been inserted in various newspapers upon a considerable scale, in the hope that as a result the demand by the public for the medical and electrical appliances sold by the company would greatly increase, it appearing that the former prosperity of the old company was in a large measure due to a system of extensive advertising. In this hope, however, the board were disappointed, and the secretary states that the advertisements did not produce sufficient business to pay expenses. The Official Receiver observes that it will be seen from the accounts that, after paying the costs of liquidation, the margin of cash left for working capital was only about £1,000. The statement of affairs shows liabilities £11,614, of which £5,472 are unsecured, with net assets *nil*. The failure of the company is attributed to loss on the trading, and to the want of funds to carry on the advertising for such a length of time as might possibly have rehabilitated the business.

Water Cooling Plant.—Mr. E. Larsen, of 19, Eastcheap, E.C., is placing upon the market Klein's patent water coolers for use in connection with steam condensing engines, and in such establishments as breweries, sugar works, and electricity works, &c. This cooler is constructed for economically cooling to a very low degree large quantities of water in a comparatively small space. It is claimed by the makers that the apparatus can be used for reducing the temperature of river water or well water if it is not cold enough in itself; for cooling of water from refrigerators or ice machines, which is now partly running to waste, but with a cooler can be constantly used; and for the cooling of the heated condensing water from steam engines, so that by means of this apparatus any steam engines, which hitherto had to be worked without condensing, can be transformed into condensing engines without any cost whatever for cooling water, as the same water is constantly used over and over again for the condensing. It is claimed that the only working expense by the self-ventilating coolers is the cost of pumping the water to the top of same; and by condensing engines, the pump attached can be arranged to do this work. Where space is limited, the coolers are worked by means of a ventilator, and the only additional cost is the power required for working it, but by steam engines this is more than regained by the better and more constant vacuum always maintained. The cooling medium is, in all cases, the atmospheric air, and the lowest degree to which the apparatus can cool is consequently limited, but even on very hot summer days, the temperature can be reduced as far as 20 degrees under the temperature of the surrounding air, and this cooling will generally be found all that is required. The cooling below the temperature of the air is produced by the evaporation of a small quantity, from 2 to 7 per cent., of the water passing the apparatus. The following are some results obtained from actual working:—Temperature of air, 86, 68, 46; temperature of the hot water, 71, 68, 60; temperature of the cooled water, 59, 53, 39; pressure in compressor by ice machines, atm., 7—8, 7, 6½; loss of water, per cent, 5—7, 4, 2—3. The above instances refer to ice machines, and the following are figures obtained for condensing water from steam engines:—Temperature of air, 86, 68, 46; temperature of heated water, 122, 113, 104; temperature of cooled water, 77, 71, 63. In connection with steam engines, the apparatus can be worked as well for jet condensers as for surface condensers, and will, it is stated maintain a perfect vacuum of from 25 to 27 inches. A higher vacuum could be obtained, but this would be in no proportion to the cost of doing so. In one brewery on the Continent, where the apparatus is at work in connection with ice machines for some time, the weekly consumption of water was reduced from 1,125,000 gallons to 80,000 gallons, equal to a saving of not less than 1,045,000 gallons per week, and at 6d. per 1,000 gallons, this would be equal to £26 weekly. The action of the cooler is simple. The heated water is pumped to the top of the apparatus, about 16 feet high, in the interior of which is arranged a large number of wooden plates in a vertical position. The water is by means of a very simple arrangement, divided over the whole surface of these plates, and flows slowly down same. By the contact with the large volume of air, which passes in the opposite direction through the cooler, the water will very quickly take the temperature of the air, and a further cooling, even as low as 20 to 25 degrees under the temperature of the air, is effected by the evaporation of a small quantity of water. In summer time, the evaporation is much larger than in the winter, and consequently the water can, even on very hot days, be cooled nearly as low as on winter days, in spite of the great difference in the temperature of the air. A large cooler on this system is at work in London for cooling the condensing water from two 350 horse-power steam engines. A great number of these coolers have been constructed up to the very largest dimensions, both in England and on the Continent, and the largest apparatus working is cooling the water from steam engine of 3,000 horse-power with the very best effect. The illustration represents one of these self-acting coolers capable of supplying cooling water for a 250 H.P. engine.



ELECTRIC LIGHTING NOTES.

Aberdeen.—The account for extras in connection with the electric lighting installation at Robert Gordon's College amounts to over £300.

Ayr.—The Town Hall, Council Hall, and other municipal buildings are to be wired and fitted for the electric light. Mr. Hammond is to report as to the system.

Belfast.—Applications for current have been received from districts where the mains are not yet laid. Inquiries are to be made as to whether the prospects of demand are such as to warrant extension of the mains.

Bolton.—At the Town Hall, on Wednesday, a Local Government Board inquiry into the application of the Corporation for sanction to borrow a further sum of £17,300 for electric lighting purposes, was held. It was explained by the Town Clerk (Mr. R. G. Hinnell) that in 1893 the Town Council proposed to borrow £40,000 for the establishment of an electric light installation, but as the result of an inquiry by the Local Government Board, sanction was given for £22,700 only, the Board reserving their consideration as to the rest until some future time. Since then the installation had been completed, and the £22,700 exceeded by some £3,000, mainly owing to the extra cost entailed for buildings. Extensions were now found necessary, as originally proposed.

Cheltenham.—At Tuesday's Council meeting, Alderman Norman reported that since commencing the working of the electric light, everything had gone on satisfactorily, and it was necessary to extend the mains to supply customers. It was also resolved to lay down an additional main from the works to a part of the town outside the compulsory area, at an estimated cost of £1,300, the committee having satisfied themselves that the return would be sufficient to meet the charges on the outlay. The Council resolved to accept an offer from Messrs. David Midgley & Sons, Manchester, to lend £2,000 at 3 per cent., for ten years, on account of the electric lighting loan.

Cowes (I. of W.)—Mr. T. H. Medhurst is to advise the District Council regarding the surveyor's report on electric lighting for the sum of 10 guineas, and has offered to attend an enquiry if necessary for 15 guineas. Messrs. Kincaid, Waller, & Manville offered to advise for 30 guineas and attend the inquiry for 10 guineas, and the Lighting Committee recommended the acceptance of this offer. The Council, however, overruled the decision on account of expense.

Crieff.—The action recently taken by Mr. W. A. Bryson, consulting electrical engineer, against the Crieff Commissioners, the Provost, and a chemical engineer, for payment of the sum of £26 5s. in respect of professional work done by him on their employment, with reference to the introduction of electric light into the Crieff burgh, has failed on the ground that plaintiff has not fully proved his employment by the defenders.

Dover.—The Electric Light Company has sent in its offer for lighting Snargate Street, and it has been accepted by the Council. There are to be 10 arc lamps of 2,000 C.P. each, 75 yards apart. The charge per lamp is to be £30 per annum, burning from dusk to dawn. The company offered to light 10 lamps on the sea front free of charge.

Edinburgh.—The buildings of the new School of Medicine, which were opened in October last, are now fitted for the electric light, current being taken from the Corporation mains. The lecture rooms are lighted by means of pendant incandescent lamps of 16 and 32 C.P. Each lecture room is provided, says a medical contemporary, with an arc lamp circuit for lantern projection, and both the arc and incandescent circuits are under the control of keys placed close to the lecture table. Close fitting dark blinds are provided in each class room, so that the rooms are available for lantern demonstrations at any hour of the day. The lighting of the anatomical department is a special feature of the installation. The wiring is carried out in three circuits. The first provides a series of bracket lamps, which serve for general illumination, and for the special illumination of wall and table preparations. The second circuit provides a pendant lamp over each dissecting table. Each of these lamps has a switch in the holder, so that the lamp can be turned on by the student when required. The third circuit provides central and side lamps for the bone room. All three circuits are under the control of the lecturer from a switchboard in his private room.

At last week's meeting of the Electric Light Committee, a requisition was received from inhabitants of Stockbridge requesting an extension of the electric light for private purposes to the Water of Leith Bridge. The necessary guarantee being forthcoming, the committee resolved on the extension, which will cost about £1,200.

Fermoy.—At the meeting of the Commissioners on 31st ult. representatives attended from Mr. Henry Simon, of Manchester, to explain the terms on which he would undertake to carry out the electric lighting work. The two schemes suggested were (1st) that Mr. Simon would carry out the work at his own expense, the light to be continuous at all seasons of the year, whether the river be flooded or not, at prices not higher than those charged for gas in Fermoy, he not requiring any guarantee from either commissioners or ratepayers beyond promises on which he could reasonably rely that 2,000 lights would be rented from him, or (2nd) that he would carry out the project of lighting the town and still save to the commissioners payment to extend over a number of years to be agreed upon. The matter is to be considered later.

Hammersmith.—The Electric Lighting Committee, after viewing installations at Chelsea, Ealing, St. Pancras, and Portsmouth, have advised the Vestry that they could not recommend them to adopt the report of Messrs. Williams and King. The vestry have, however, decided to advertise for complete schemes and tenders for boilers, machinery, mains, &c., necessary to carry out the work included in the compulsory area. After that the Vestry will consult an engineer for advice.

Hampstead.—Last week we stated in error that Mr. Sayers had been appointed chief electrical engineer to the Vestry. This should have read chief *assistant* electrical engineer. We had already informed our readers that Mr. Geo. H. Cottam had been appointed to the post of chief engineer.

Islington.—In reference to our last week's notice regarding the lighting for the Military Tournament, Messrs. F. A. Glover & Co. inform us that extensive alterations and additions to the most important part of the electric lighting, viz., that of the main hall, was carried out by them, besides the lighting of the galleries by arc lamps. The work was done for the Royal Agricultural Company.

The report of the Finance Committee, to which we referred in our issue for May 17th, has been adopted by the Vestry.

Kendal.—The Board of Trade have communicated to the Parliamentary agents of the Corporation that the Windermere Electricity Company have not included Kendal in the provisional order to be applied for.

Kensington.—The London County Council has repeated with emphasis its former decision to withhold its consent to the construction of a transformer chamber by the House-to-House Electric Light Supply Company in High Street, Kensington. The Council has left the matter for the decision of the Board of Trade, upon appeal.

Limerick.—Some extensive grocery, &c., premises in George Street, have been fitted up for electric lighting. There are a 5-H.P. gas engine, 32 incandescent lamps (8 to 32 C.P's.) and one 500 C.P. arc lamp.

London, E.C.—Messrs. John Howell & Co., Limited, of St. Paul's Churchyard, who were formerly connected to the mains of the City of London Electric Lighting Company, found the cost so great as compared with gas, that they have now, under the advice of Mr. Albion T. Snell, had complete plant of their own put down in the cellars. Power is derived from a 12-nom. H.P. gas engine, driving a 12-unit dynamo, and a battery of accumulators. The installation comprises at present about 200 incandescent lamps placed in the basement, counting-house, some parts of the warehouse, in the private house, &c. The plant has now been at work for about three months.

Lynn.—The electric lighting question is receiving consideration at the hands of the Council.

Peterborough.—The Council has the appointment of an electrical engineer under consideration at present.

Portsmouth.—The Borough Asylum Committee have resolved to introduce the electric light into their establishment, at an estimated cost of £550.

St. Helens.—We understand that the Gas and Lighting Committee have at last definitely decided upon a scheme of electric lighting for the borough. The original plans, which involved an expenditure of between £30,000 and £40,000, have been so modified that the actual expenditure to be incurred will not be greater than £10,000.

Sunderland.—The County Council has under consideration a proposal for providing electric lanterns for the police. One objection raised to an alteration is that the policemen derive warmth from oil lamps in the winter time, which they would not have with electric lamps.

Thurmaston.—The *Leicester Post* says that at the last District Council meeting the Wigston Electrical and Engineering Company submitted (by Mr. Lavender in person) an estimate for the electric lighting of the village. For the lighting of the streets by arc lights he had made an approximate estimate of £1,000, and the annual cost of working and maintenance he put down at £189. The present cost of gas at 4s. 2d. per 1,000 was £72 16s, but on adopting electricity instead of the 240 C.P. which they had at present, the electric light would give them 10,500 candle-power. The approximate estimate of an installation for private use with incandescent lights was £2,000, and on the basis of 500 lights the annual costs would be £331. He pointed out that the profit of the private supply could be devoted to defraying the cost of the public supply. It was decided to defer the matter for three months.

Train Lighting.—Mr. Maurice Pitman, of Sandymount, has received the contract from the Great Northern Railway Company, Ireland, for the electric lighting of their new breakfast car, which is in course of construction at their works at Dundalk. There will be 15 lamps of 5 C.P. each, and the car will be lighted either from its own accumulators, or from accumulators in the guard's van, which are charged from an axle-driven dynamo, already mentioned in our columns. There will also be a complete system of electric bells for calling waiters. This car is to run on the Limited Mail Train, between Dublin and Belfast. This is the third carriage Mr. Pitman has done for the company in nine months, the other two being a dining and drawing-room car.

Wandsworth.—The Guardians have granted permission to the County of London and Brush Provincial Electric Lighting Company to lay their mains in the Board's district; "but the Board disapproved of the construction of the proposed converting stations or transformer chambers, and the company are to be informed that the Board are of opinion that the required stations or chambers should be constructed on land not forming part of the public way."

Winchester.—On Thursday last week the Mayor and some members of the Corporation paid a visit to Portsmouth municipal buildings, and in the evening inspected the electric light.

TELEGRAPH AND TELEPHONE NOTES.

Communication with the Orkneys and Shetlands.—H.M. telegraph steamer *Monarch* arrived at Kirkwall on 30th ult. from the South of England. The vessel is to be engaged in repairing or relaying a new cable between Fair Isle and Shetland, and will afterwards lay a cable from Gousay to the mainland. It was reported that North Ronaldshay would have been connected with the Shetland cable, as it is the most isolated island of the group, and a place where many shipwrecks take place, and is the most northern lighthouse in Orkney.

Dublin Telephone Service.—At a meeting of the Dublin Mercantile Association the other day a resolution was passed expressing great dissatisfaction with the telephone service.

Telegraph Rates between India and Mauritius.—We have recently called attention to the high rate for telegrams to Mauritius from Europe. It will be remembered that the cable to Mauritius was laid under contract with Her Majesty's Government. We give here an extract from a copy of a Treasury Minute on this subject:—"The necessity for telegraphic communication with the Island of Mauritius has for some time been one of admitted urgency. The governments of that colony and of the Seychelles proved their sense of the importance of the matter by consenting to contribute annual sums of £7,000 and £1,000 respectively towards the subsidy required for a cable, and the Government of India agreed to share the balance of cost with this country. Under these circumstances, tenders were invited for the service." From this it will be observed that the Indian Government bear their share in the payment of the subsidy, and yet we notice that according to the "Indian Telegraph Guide," corrected to July 1st, 1894, the cost per word for a telegram from India to Mauritius is 7r. 3a. (=about 8s. 5d.); whilst a telegram may be sent from India to New York for 4r. 11a. (=about 5s. 6d.) per word. These figures attract the attention to the possibilities there are for a considerable reduction in the rates between India and Mauritius. This should not be difficult to effect, as the shares of the company which own the line to Mauritius are, we understand, held almost entirely by the Eastern Telegraph Company.

The "Life" of a Submarine Cable.—In the course of a controversy conducted in the *Times* last year between Sir Charles Tupper and Sir John Pender on the subject of a Pacific cable, one of the factors in the discussion was as to the period at which, for purposes of amortisation, the "life" of a submarine cable should be taken. In Sir John Pender's calculations, this period was taken to be 14 years. We notice, however, that at the general meeting of the West India and Panama Telegraph Company the chairman of that company, Mr. C. W. Earle, in speaking of the reserve fund, said that this "was calculated upon the basis of the life of a cable which they estimated at 30 years." Now, it must be borne in mind that this company's cables are laid in a coralliferous sea, and in the vicinity of some of the deepest water known in any ocean; the depth to the north of Porto Rico being 4,561 fathoms. The expression of Mr. Earle's opinion as to the "life" of a cable carries with it a certain value, as besides being chairman of the West India and Panama Telegraph Company, Mr. Earle is director of four other important telegraph companies, one of these being the Eastern Extension, Australasian and China Telegraph Company, of which Sir John Pender is chairman.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Dublin Tramways.—At the last meeting of the Blackrock Town Commissioners, complaints were made of the obstruction caused by the Dublin Southern District Tramway Company, who are at present relaying their lines. It was also complained that in some cases they were putting the upright posts in the middle of the footpaths instead of at the sides. The matter has been referred to the engineer.

Kidderminster-Stourport Proposed Tramway.—The Watch Committee of the Town Council has had an interview with a representative of the electrical company which proposed to put down a tramway from Kidderminster to Stourport.

Isle-of-Man Tramways.—A special meeting of the Douglas Town Commissioners was held last week for the purpose of considering the recommendations of the Improvement Committee with reference to the disposal and vesting of the tramway concern in Douglas, and the proposed construction of a tramway to Upper Douglas. The following offer from the company was considered:—"That in return for a double line throughout on Douglas Bay line, and an extension of lease for 21 years, in addition to the three years yet unexpired, this company offers the Commissioners an annual payment of 15 per cent. upon the gross traffic receipts of such line, the minimum payments to be £1,500 per annum. This company also undertaking to construct and work a tramway to the upper part of the town, upon the necessary powers being obtained (the company having the option to adopt any system of traction other than steam or electrical power). In the meantime, the company to run a liberal service of busses for this year; the Commissioners, on their part, granting leave to the company to at once double that part of the Bay line between the Iron Pier and Castle Terrace, so as to be in use for the coming season. The above payment to commence as from the date of agreement. As the Commissioners consider it to be unadvisable to work the Bay Line by electrical power, the directors under the circumstances consider it unadvisable to lay down an electrical equipment or to supply electric light. The only object they had in view was to work a uniform system as now in operation on the Laxey line, as, owing to its cheapness, it would allow the company to reduce their working expenses, and so admit of a more liberal annual payment." The discussion continued for some hours, and, in the end, was adjourned to June 10th.

North Staffordshire Tramways.—The secretary of the North Staffordshire Tramways Company has written to the Stoke-upon-Trent Council respecting the proposal by the company to work the tramways by electricity by means of overhead wires. A long discussion took place, and it was resolved not to come to any decision as to the scheme for the adoption of electricity for the motive power without further information. A sub-committee was appointed to confer with the tramway company on the matter.

CONTRACTS OPEN AND CLOSED.

OPEN.

France.—June 8th. Tenders are being invited for (1) the supply and erection of the necessary plant for the electric lighting of the Boucicaut Hospital, and (2) for the supply of the necessary electric lighting fittings. Tenders should be addressed to L'Assistance Publique, Avenue Victoria 3, Paris.

Italy.—The Italian Military Authorities at Pavia are at present inviting tenders for the supply of 105,600 metres of rubber-covered telegraph wire 1·6 mm. diameter. Tenders to be addressed to the Direz Offic di Costruz Mat. Genio Milit, Pavia, Italy.

London.—The Secretary of State for War has given notice that purchases of specific quantities of a variety of articles will probably be made from time to time during the current year. The list includes the following items:—Chain (iron, light and heavy), electrical instruments (submarine mining), India-rubber goods, lamps and lanterns, oils, spades and shovels, telegraph cable and wire. Manufacturers who may be desirous of tendering should apply to Mr. G. Lawson, Director of Army Contracts at the War Office, Pall Mall, S.W., by letter. Applications unaccompanied by references will not be noticed. Firms whose names are already on the War Office list need not apply, as forms for tendering will be sent to them in due course.

Roumania.—July 29th. The Municipal Authorities of Braila, Roumania, are inviting tenders for the concession for the construction and operation of an electric tramway along the main streets of the town.

Rangoon.—November 4th. The Municipal Committee is inviting tenders for electric lighting. Particulars to be obtained from Messrs. Ogilvy, Gillanders & Co., 67, Cornhill, E.C.

Spain.—June 27th. Tenders are being invited by the Municipal Authorities of Medina del Campo, in the province of Valladolid, for the concession for the electric lighting of the town during a period of 20 years, the Municipal Authorities reserving the right to annul the concession at the end of eight years. Tenders are to be addressed to the Ayuntamiento de Medina del Campo (Valladolid).

Spain.—The Municipal Authorities of Astonga (Leon province), are at present inviting tenders for the concession for the electric lighting of the town during a period of 20 years. Tenders are to be sent to the Ayuntamiento de Astonga (Leon).

St. Helen's.—Tenders are invited by the Corporation for boilers, alternators, switchboards, cables, transformers, &c., &c., in connection with the proposed electric lighting of the borough. For further details see our advertisement pages.

Wakefield.—The City Council on 17th inst. decided to advertise for tenders for carrying out the electric lighting works at a cost of over £20,000.

York.—June 10th. The North Eastern Railway Company invite tenders for the undermentioned articles in such quantities as they may require, during the six months ending December 31st, delivered, carriage paid, at the company's telegraph stores at York:—1. Telegraph apparatus. 2. Telegraph wires and line stores. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York, and tenders must be sent to the secretary, Mr. C. N. Wilkinson, York.

CLOSED.

Cheltenham.—Two tenders were received for the wiring and lighting of the Library with the electric light—Messrs. R. E. and C. Marshall at £105 10s. 6d., and Mr. A. G. Sanders at £118 9s. Messrs. Marshall's tender was accepted.

NOTES.

Exhibition of Railway Appliances.—At the Imperial Institute on Saturday was inaugurated an exhibition of railway appliances and inventions, which is to remain open till the end of August. The first International Railway Congress is to be held at the Imperial Institute from June 26th to July 9th, and the exhibition is the outcome of a suggestion that advantage might be taken of the occasion to bring under the notice of the large number of British and foreign delegates attending the congress the productions of manufacturers in this department of British industry. The Exhibition was opened by the Rt. Hon. the Lord High Chancellor (Lord Herschell, G.C.B.), who, after a brief speech in the new Lecture Hall, explained the objects and scope of the Exhibition, proceeded to the Exhibition building, unlocked the door, inspected the exhibits, and declared the Exhibition open. The Exhibition comprises examples of most of the recent improvements in carriage construction, warming, heating, and ventilating appliances, signalling apparatus, and many other minor details designed to increase the comfort and safety of the railway passengers and railway servants. Prominent amongst the exhibits is that of Messrs. Saxby & Farmer, consisting of a full size illustration of their union of lock and block systems, with electric slot replacer and improved mercurial rail contacts, block instruments, relays, &c. The system used by Saxby & Farmer in the interlocking and signalling of the Tower Bridge is also shown, as well as an electric train staff or tablet apparatus for facilitating the working of traffic on single lines of railway. Messrs. Siemens Bros. & Co. show a number of telegraph, telephone and electric lighting samples; Mr. R. Aylmer, Leclanché cells, telephones and bells; Messrs. Girdlestone, Tatham & Co., Andersen's arc lamp, telephones and electric light switches and fittings; Mr. Wilfrid S. Boult, a model of a magnetic apparatus for signalling passing trains; "Le Carbone," Lacombe cells, carbons and carbon dynamo brushes; Messrs. Krupka & Jacoby, Lessing's dry battery. The Gloucester Waggon Company and the Decauville Company have on view carriages and waggons adapted for light railways, and Messrs. R. White & Son illustrate different styles of permanent way for such lines. In all there are about 100 exhibitors, and every exhibit was in place, ticketed and catalogued on the day of opening. The Exhibition building is lighted with Andersen arc lamps in "Holophane" globes. As this is the first time these globes, in their improved form, have been publicly used in this country, the occasion is worth noting.

An Anglo-French Combination.—The company owning the Heilmann electric traction system has received an order from La Compagnie de l'Ouest for two electric locomotives, to be completed, one in August and the other in October or November. Messrs. Willans & Robinson are to supply the engines, Messrs. Cail the boilers and mechanism, and Messrs. Brown & Boveri the electrical plant. The company has conceded to Messrs. Willans & Robinson the patent rights of the system for England, India, and the Colonies, to Messrs. Brown & Boveri, the same for Switzerland, Germany, and Italy, and to a Russian syndicate that for Russia. On the other hand the company have obtained the sole right to manufacture and sell Messrs. Willans & Robinson's engines in France. The present company will form itself into a new one, entitled "Société Industrielle des Moteurs Electriques et à Vapeur," with a capital of 4,000,000 francs. We are indebted to *La Semaine Electrique* for this information.

Lectures.—Before the Halifax Scientific Society on May 29th, Mr. C. Worsnop delivered a paper on the "History and Application of Electro-metallurgy." Mr. Willis gave experiments in electrotyping in silver, and examples of electrotyping in gold were also exhibited.

Bergen Electrical Ferry Service.—The *Electrotechnische Zeitschrift* recently contained an illustrated description of the electrical ferry service at Bergen, Norway, and we abstract the following account thereof from the *Electrical World* of New York:—After a consideration of steam, petroleum, and electric boats, it was finally decided that the latter possessed the greatest merit for the use proposed. The ferry plant consists of eight boats, a charging station, and a boat harbour. Work was begun in May, 1894, and by August the ferry was started. The boats are built symmetrically fore and aft, and provided with a screw and rudder at either end in order that turning when leaving the landing places may be avoided, that they may be more easily steered, and for other reasons. The screws are on a common shaft, direct coupled to the motor. A series-wound motor is used, weighing about 660 lbs., and rated at 3 H.P.; it is placed in the middle of the boat under the flooring. Its construction is such that the insulation cannot be injured by any bilge water which may collect. The radically fastened carbon brushes work without sparking or heating of the commutator, whether the armature is turning forward or backward. The storage batteries are placed partly under the flooring and partly under the seats. The plates are of the Hager type, and those of each battery weigh about 3,080 lbs., and have a capacity of about 20,000 watt-hours. The battery consists of 32 cells in series, and weighs altogether 5,280 lbs. In order to control the speed, a special switch is provided, which operates by cutting different parts of the field coils of the motor in and out, and so causes the boat to go ahead, astern, slow and faster by regular gradations. In the middle of the boat, over the motor, there is a cylinder, about 4 inches in diameter, through which pass the conductors to the motor and the accumulators, and the connections to the steering apparatus. On the head end of this cylinder are two wheels, each 16 inches in diameter, placed one above the other, the upper of which works the rudder, while the lower controls the movements of the regulating switch. The average speed, with a power of 2,300 watts, is about 5 miles an hour. As the distances between the landing places are not great, this comparatively low speed has been found ample, and owing to the crowded condition of the harbour, it is even necessary in order to avoid accidents. The bearings of the motor and the shaft are self-lubricating while running, so that the man at the wheel, who operates the boat alone, can give his individual attention to steering it. The boats are run under 5 minutes' headway, and from 7 o'clock in the morning to 9.30 at night in the winter, while in summer the daily service is lengthened. Each boat runs about 37½ miles a day. Up to this time about 1,800 passengers, on the average, have been carried by the ferry each day. After the day's work is over, the boats return to the charging station, where the accumulators are charged during the night, and the necessary cleaning done and repairs made. The charging station is fitted with a compound portable steam engine, a dynamo of 30 H.P., and a suitable switchboard. The total cost of the plant was as follows:—

Eight boats, including duplicate parts	$11,900
Charging station, boat harbour, and landing places ...	9,520
Total amount	$21,420

During eight months of uninterrupted operation the plant has proved excellent in every respect.

Repairing Commutators.—Writing to the *Scientific American*, a correspondent replies as follows to another correspondent who asked for some composition for filling cracks in a commutator:—"You reply that the only way to repair will be to take the commutator apart and replace the mica. But if he happens to have no appliances for this work, a temporary repair can be made of thick shellac solution and dry plaster of Paris. Fill the crack with the shellac, then put on the plaster, kneading with a knife blade until it is stiff and smooth. Let it dry five or six hours or longer, before scraping off the top even with the surface. It should be thoroughly dry before the armature is used. I have used this method for repairing street railway motor armatures for more than a year, and no armatures have come back in that time for a fault due to this filling."

Researches on Polarisation.—Some interesting experiments on polarisation with solid and liquid cathodes have recently been concluded by J. Roszkowski. The details and a description of the arrangements may be found in the *Zeitschrift für Physikalische Chemie*, xv., pp. 267, 305. We can only find space for noticing the chief results of the research. Variations in the size, material, and surface of the solid cathodes were made: these were chiefly platinum, and their surfaces were polished, platinised, and heated to redness, and covered with scratches in the different experiments. Very different values were obtained for the polarisation, the highest being when the surface was scratched and the lowest when it was simply platinised. The platinised cathode also gave the curve of polarisation, polarising E.M.F., approximately a straight line of inclination $\tan^{-1}\frac{1}{3}$. In no case does a maximum value occur, and the differences the author considers to be due to different occluding powers of the surface. In the experiments with liquid cathodes, these consisted of mercury and amalgams of lead, zinc, and copper, and curves were prepared embodying the relations of polarisation, and polarising force were obtained. In the case of the zinc and lead amalgams the curves are at first parallel to the axis of abscissæ, after which, like the curves for platinum and silver they become approximately straight lines; but with inclination $\tan^{-1} 0{\cdot}62$, and no indication of a maximum is apparent as before. A cathode of Wood's alloy was examined both in the solid and liquid state, and the curves obtained were almost identical, and closely resembled those previously obtained, being at first parallel to the axis of abscissæ. Hence in this case the nature of the surface has but little influence on the polarisation, which, if the E.M.F. is above a certain value, is approximately a linear function of the polarising force.

Commercial Potassium Zincate by Electrolysis.—Considerable attention has been attracted of late to the use of zinc-copper accumulators, and this has suggested to P. Schoop the desirability of studying the preparation of alkaline solutions of zinc hydroxide such as have been used in the well-known Lalande-Chaperon element, which is capable of being used both as a primary and a secondary cell. The outcome of his investigation is a technical process for the preparation of potassium zincate. The apparatus in which this is effected consists of a copper vessel, within which fits a cylinder of spongy copper. Within this again there is a zinc cylinder resting on a layer of magnesia which serves the purpose of keeping the zinc out of contact with the copper. A steel screw serving as an agitator is placed within the zinc cylinder; it is worked by an electric motor, and its function is to ensure the circulation of the electrolyte—a solution of caustic potash. The whole apparatus rests within a clay cylinder, round which is wrapped a nickel spiral heated by electric current, the temperature being thus easily maintained at about 60° C. The process is started by making the copper vessel the anode and thus oxidising the spongy copper. The current is then reversed and the zinc dissolved, while the copper oxide serves to suppress the equivalent of hydrogen which is formed. The electrolyte thus obtained is freed from its impurities by subjecting it to a supplementary electrolysis in a separate vessel with zinc electrodes and a porous diaphragm of magnesia. The ions of negative impurities, *e.g.*, chlorine collect on that side of the septum which contains the anode, while on the cathode side metallic impurities are precipitated on the zinc plate. In Schoop's paper, which may be consulted in the *Zeit. für Elektrotech. und Elektrochem*, vi., p. 205 and p. 347, details are given which relate to the investigation from which the above process resulted.

Better Late than Never.—We received last Tuesday morning (June 4th) an invitation requesting our presence at the Graduation Exercises of the Massachusetts Institute of Technology, held *on May 28th*. Perhaps it was intended for our New York namesake?

New Departure in Arc Lighting.—Messrs. Drake and Gorham will in a few weeks' time put on the market the Jandus Arc Lamp, which will burn for 200 hours with one pair of carbons.

Fires Caused by Incandescent Lamps.—We cull the following from the *Scientific American*:—"An investigation into the cause of a fire in a Winter Street dry goods store, in Boston, recently, resulted in demonstrating that an incandescent electric lamp will generate sufficient heat to set inflammable material into a blaze. The fire in question, for which a still alarm was given, was caused by allowing an incandescent lamp to remain for a few moments on a pile of cotton cloth in the packing room. The person in charge left the room for a few moments, not dreaming but that it was safe to leave the lamp on the cloth. When he returned the cloth was blazing. The fire was soon put out, and not much damage was done. This case recalls one reported from Louisville, Ky., a few months ago, the *Boston Journal of Common* adds, which demonstrates the same thing. The fire started, says the *Insurance Herald*, while the window dresser was preparing a Christmas snow scene. The window was lighted with incandescent lights, which, it appears, had not been changed for a year, except when made necessary by accidental breakage. The carbon in an incandescent globe has a life of 600 hours, and as it wears out the carbon loop offers increasingly less resistance to the current, and, therefore, increasingly more heat is thrown off upon the glass bulb and even upon the metal stems to which the globes are affixed. When a new light is attached the globe becomes only warm under continuous use, but after it gets old the globes are hot and the stems attain burning heat. The dresser was filling the floor of the window with loose cotton upon cheesecloth, to represent snow. This was packed closely around the stems and globes of the electric lights, and there is no doubt that the inflammable cotton, touching the burning hot stems and globes, caused the fire."

Baths for Electro-Nickelling.—A brief *resumé* of the different electro-nickelling baths, as used in the chief German factories, is given by an anonymous writer in *Dingler's Polytechnisches Journal*, 293, p. 69. It is claimed that they all give excellent results *when they are carefully handled*. The composition of these baths is as follows:—1. 8 kilogrammes of nickel ammonium sulphate in 100 litres of water, made slightly alkaline with aqueous ammonia, and then slightly acidified with citric acid. 2. Five parts of nickel sulphate neutralised with ammonia solution per 100 parts of water, to which 3·75 parts of ammonium tartrate and 0·025 parts gallotannic acid are added. This bath gives a homogeneous, white and smooth reguline deposit, even when of great thickness. 3. 2·75 parts of nickel acetate, 2·5 of calcium acetate, and 100 parts of water are mixed together, and to the mixture is added 0·7 part of acetic acid (sp. gr. = 1·047), after which it is filtered, and is then ready for use. This is the best form of Pott's formula. 4. Five parts of nickel ammonium sulphate, two of ammonium sulphate, 0·5 of citric acid in 100 parts of water. The mixture should be boiled and filtered before use. 5. Eight parts of nickel ammonium sulphate, one of ammonium chloride in 100 parts of water. To this bath may or may not be added 0·5 part of barium oxalate. 6. Six parts of nickel ammonium sulphate, 3·5 ammonium chloride, and 2·5 parts ammonium sulphate in 100 parts of water. 7. Five parts nickel ammonium sulphate, one of ammonium sulphate, and 100 parts of water. [This bath is stated to be especially used in the electro-nickelling of cast-iron.] 8. Five parts of ammonium sulphate, 2·5 parts of boric acid, and 100 parts of water. In commenting upon these baths, the author refers to Powell's statement that the addition of not more than 1 to 8 grammes per litre of benzoic acid, or of a benzoate to any suitable nickel bath, assists materially in producing a good and pure deposit of the metal. His experience with baths containing boric acid is that they give good deposits upon smooth surfaces, but that they refuse to cover cavities or hollows. He has found, however, that this difficulty may be surmounted by the addition of sodium chloride to the bath, and he recommends the following:—9. Five kilogrammes of nickel ammonium sulphate are dissolved in 100 litres of water. To this must be added 2·5 (or 1·25) kilogrammes of boric acid, and 1·25 kilogrammes of sodium chloride. The mixture is then boiled, acidified with citric acid, neutralised with ammonia, and filtered. Nickel chloride is also found to be a good substance by the author in preparing baths containing boric acid. It should be used in the proportion of 5 : 2 or

2 : 1. These baths, however, are not suitable for depositing nickel on iron or steel, since baths which contain chlorine are apt to set up rusting on the surface of the metal. Except for the expense, the author would prefer to use baths containing citric, benzoic, tartaric, or other weak acids when iron and steel are to be coated.

NEW COMPANIES REGISTERED.

Val d'Osta Electric Power Company, Limited (44,205).—This company was registered on May 27th with a capital of £80,000 in £10 shares, to acquire, take up, and hold concessions for the utilisation of water, &c., in any part of the world, and to carry on the business of suppliers of electric light and power in all its branches. The subscribers (with 25 shares each) are:—O. Brown, 32, Victoria Street, S.W., civil engineer; F. A. G. Brown, Genoa, Italy, merchant; A. Bigio, Genoa, merchant; N. Brand, Genoa, engineer; P. Bright, 2, Newgate Street, E.C., engineer; R. F. Austin, 8, Union Court, E.C., solicitor; J. H. Jones, 8, St. Martin's Place, W.C., contractor; W. G. Kent, 119, High Holborn, engineer. The number of directors is not to be less than three nor more than seven; the subscribers are to appoint the first; qualification, £250; remuneration, £100 each per annum, and a share of the profits divisible. Registered by H. D. Kimber & Co., 79, Lombard Street, E.C.

English Incandescent Gas Share Company, Limited (44,214).—This company was registered on May 27th with a capital of £500,000, in £1 shares, to acquire shares in the capital of the Incandescent Gas Light Company, Limited, to enter into agreements (1) with E. Hayes and E. Littlejohn, (2) with J. Moeller and E. Littlejohn, and (3) with F. C. Stoop & Co., and to carry on the business of manufacturers and dealers in incandescent lights and other apparatus, suppliers of light, heat, electricity, and motive power, electricians, &c. The subscribers (with one share each) are:—G. de la P. Beresford, Eamont, Cheltenham, Major-General; J. Moeller, 2, Queen's Park Gardens, Streatham, manager; L. de Fonblanque, 5, Pitt Street, Campden Hill, W., secretary; F. C. Stoop, 4, Hercules Passage, E.C., stockbroker; K. H. Buchanan, 14, Palmer Street, S.W., civil engineer; E. Hayes, 236, Upton Lane, E., accountant; S. W. Scullin, 18, Leathwaite Road, Clapham, clerk. The number of directors is not to be less than three, nor more than seven; the first are Major-General G. de la P. Beresford, Major C. Jones, and J. Moeller; qualification, £500; remuneration, £300 per annum each, and £100 extra for the chairman. Registered by Francis & Johnson, 26, Austin Friars, E.C.

CITY NOTES.

Elmore's German and Austro-Hungarian Metal Company.

The report of the directors of Elmore's German and Austro-Hungarian Metal Company, Limited, for the year ending December 31st, 1894, states that the accounts call for little remark, as the figures have changed but little from those of 1893. As stated in the last report, the second debentures have been reduced from £49,480 to £25,980 by redemption. The terms of the redemption were very favourable to the company, and the great reduction of the capital was carried out at a cost of only £11,750, and this in preference shares. The amount advanced to the "Metall" Company by this company is now £15,947. As security for the amount this company holds two mortgages upon the property, amounting together to £15,000, which are a first charge, subject only to the payment of the balance of the final instalment of the purchase money. With regard to the Metall Company's accounts, these also call for but little remark, the principal alterations in the figures being the additions and improvements to buildings, machinery, and plant, the increase in materials and stores in hand, and the increase of amount due from sundry debtors. The amount due to sundry creditors is somewhat large, owing to the amounts payable to contractors on account of the new plant. The directors regret that the amount standing to the debit of profit and loss account has increased. This is, to a considerable extent, caused by the heavy depreciation account, which has been deducted as heretofore. Although the new plant was not completed until the end of 1894, the sales had increased from £3,194 in 1893 to £8,131 in 1894, and the loss on factory account was practically *nil*. The working of the company was greatly restricted by want of funds during the early part of the year. With regard to the general work of the factory to date, the directors are able to report satisfactory progress. The new plant has proved to be of great value, and is a marked improvement upon the plant originally erected. The rate of progress has not been so rapid as the directors could have wished, delays having occurred owing to the severe frost, an accident to the draw-bench, and other causes which have seriously retarded work. Notwithstanding all this, however, the sales are over three times as great as for the same period last year, and the directors see no reason why the rate should not now increase to a much greater extent. The number of customers increase weekly; indeed, the directors find the question of orders the least difficult to deal with, as although they do not advertise, and have no travellers, they are in receipt of an abundance of good paying orders. They are also able to report that the company has entered into further contracts for the supply of copper tubes, including one with the Imperial State Railways. The directors purpose later to still further increase the number of tanks in the factory. This can be done at a nominal cost, and will greatly increase the earning capacity of the factory.

The West Coast of America Telegraph Company, Limited.

The report of the directors for the year ended December 31st, 1894, to be presented at the 18th ordinary general meeting on June 11th, 1895, states that the gross income for the year 1894, as shown in the annexed revenue account, was £21,753 12s. 2d. as against £15,096 4s. 3d. in 1893, and in order to provide for the payment of the debenture coupons, it was necessary this year to take £10,400 12s. 9d. from the reserve. The sterling value of the local traffic for 1894 was again most seriously affected by the low rates of exchange both in Peru and Chile, the value of the dollar in Chile having fallen as low as 10⅝d, and the average rate for the year was 12d., as against 14d. in 1893. In view of the recent legislation in Chile, by which the paper currency of the Republic is to be replaced from June 1st by gold, on the basis of 18d. to the dollar, it may fairly be hoped that exchange in the future will not greatly fluctuate from that figure. It may also be anticipated that the use of the telegraph for commercial purposes will continue to increase. The total expenses were £20,154 4s. 11d., against £19,632 16s. 6d. in 1893. The company's cables and landlines, as well as the repairing steamer *Retriever*, continue to be maintained in a state of efficiency, consistently with which every possible economy is practised with regard to the expenditure. The direct service between the company's stations and Europe, *viâ* Madeira, appears to have afforded every satisfaction to the public. The members of the board retiring, in accordance with the articles of association, are Mr. J. Denison Pender and Mr. Frederick Walters, both are eligible, and offer themselves for re-election. The auditor, Mr. John Francis Clarke, retires, and is eligible for re-election.

Consolidated Telephone Construction and Maintenance Company, Limited.

Mr. C. L. W. Fitzgerald presided at the annual meeting of this company held at Winchester House yesterday. In his opening statement the chairman referred to the result of the company's operations for the year. Competition had become much severer; wages and cost of materials were about the same each year, but they found that their profits were always lessened. They were the victims of free trade, foreign competition, and high wages. They hoped for some mitigation of these by removing the works into the country. He held out great hopes from the agreement which had been made for the manufacture of the capsule battery. He saw the possibility of the company making large profits out of the sale of this article. The next thing was the taking up of the manufacture of general electrical apparatus, which would be considered at the conclusion of the present meeting. What he considered the most important thing in the report was the result of the lawsuit in Belgium. The action was brought against infringers of their patents in Belgium, the first one being in 1886, against the Zurich Telephone Company. Delays arose out of the necessity of providing security. In March, 1889, the case came on before the experts. Two years after the report was delivered (in 1892) judgment was given against this company; the result of the appeal was in favour of them. Damages had not yet been assessed, but their solicitor in Belgium put them at a high figure. As would be seen from the report, the directors had deferred payment of their fees. The chairman then went through the figures of the report in detail.

A Shareholder spoke very strongly with regard to the company's position. When, with the large capital of the company, they could only make £1,400, he thought the company was on its last legs.

The extraordinary meeting was then held for the purpose of altering the articles of association, which would enable the company to manufacture, buy, and sell, general electrical apparatus, and also to change the name of the company to "The Consolidated Telephone Construction and Manufacturing Company, Limited."

The Chairman thought the telephone business was too limited, and he thought it advisable that they should make other apparatus, and try to make a profit out of it.

The resolutions submitted for that purpose were passed unanimously.

Hobart Electric Tramway Company, Limited.—The annual general meeting of this company is to be held on 11th inst., at the London offices, College Hill, E.C.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending June 2nd, 1895, amounted to £929; week ending June 3rd, 1894, £869; increase, £60; total receipts for half-year, 1895, £20,533; corresponding period, 1894, £20,013; increase, £520.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of May, 1895, amounted to £2,107, against £1,594 in the corresponding period of last year.

The Liverpool Overhead Railway Company. The receipts of this railway for the week ending June 2nd, 1895, amounted to £1,146; corresponding week last year, £830; increase £316.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 31st, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,589.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation May 29th.	Closing Quotation, June 5th.	Business done during week ended June 5th, 1895. Highest.	Lowest
173,400/	African Direct Teleg., Ltd., 4 % Deb.	100	...	4 %	4 %	102 —105	102 —105	...	...
1,012,880/	Anglo-American Teleg., Ltd.	Stock	£2 15s.	£2 11s.	£2 2s.	46 — 48	46 — 48	47	46
2,993,560/	Do. do. 6 % Pref.	Stock	£5 10s.	£5 2s.	£4 4s.	84½— 85½	84½— 85½	85½	85½
2,993,560/	Do. do. Defd.	Stock	...	...	...	8½— 8⅝	8½— 8⅝	...	...
130,000	Brazilian Submarine Teleg., Ltd.	10	6½% §	6½% §	...	12¾— 13¼	13 — 13½	13⅜	13
75,000/	Do. do. 5 %, repayable June 1906	100	5 %	5 %	...	111 —115	111 —115	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	10%‖ §	... §	...	3 — 4	3 — 4	3 5/16	3½
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	154 —158	154 —158	160	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 % §	2 % §	1½%	1/16— 3/16	1/16— 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	13 — 14	13 — 14	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	20 — 21	20 — 21	...	...
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4 %	4 %	4 %	3½— 4½	3½— 4½	...	...
6,000	Do. do. 10 % Pref.	5	10 %	10 %	10 %	9¾— 10½	9¾— 10½	...	...
30,000/	Do. do. 4½ % Debs of £50, Nos. 1 to 1,600	...	...	...	4½%	105 —108%	105 —108%	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½% §	2½% §	2 %	9¼— 9¾	9¼— 9¾	9⅝	9¼
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½% §	...	16½— 16⅝	16½— 16⅝	16⅝	16½
70,000	Do. 6 % Pref.	10	6 % §	6 % §	...	17½— 17¾	17½— 17¾	17 7/16	...
102,100/	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	...	103 —109	106 —109	...	...
1,297,837/	Do. 4 % Mort. Deb.	Stock	4 %	4 %		123 —126	123 —126	125	123½
250,000	Eastern Extension, Australasia and China Teleg., Ltd.	10	7 %	7 %	7 %	16 7/16— 17⅛	16 7/16— 17⅛	17 1/16	16 15/16
54,100/	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5 %	104 —108	104 —108	...	...
194,300/	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5 %	105 —108	105 —108	...	...
320,000/	Do. 4 % Deb. Stock	Stock	4 %	4 %	4 %	124 —127	124 —127	...	...
95,100/	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5 %	104 —108	104 —108	...	...
129,100/	Do. do. do. to bearer, 2,344 to 5,500	...	5 %	5 %	5 %	105 —108	105 —108	...	
300,000/	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	4 %	4 %	4 %	107 —110	107 —110	107½	107
200,000/	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4 %	111 —114%	111 —114%	...	..
180,227	Globe Telegraph and Trust, Ltd.	10	4⅜% §	4⅜% §	...	10 — 10½	10 — 10½	10 3/16	10 1/16
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	...	16⅞— 17⅛	16⅞— 17⅛	17⅛	16⅞
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜%	8⅜%	8⅜%	21¾— 22¼	22 — 22½	22¼	22
190,000/	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	105 —108	105 —108	106⅜	106
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	44 — 47	44 — 47	46	45¼
37,548	London Platino-Brazilian Teleg., Ltd.	10	2 %	2½%	1¼%	5 — 7	5 — 7	...	...
100,000/	Do. do. 6 % Debs.	100	6 %	6 %	6 %	106 —110	106 —110	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	... — ...	... — ...	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	*nil*	4 %	...	1¼— 2¼	1¼— 2¼	...	...
484,597	National Teleph., Ltd., 1 to 438,984	5	5 % §	5 % §	5 %	5⅜— 5⅝	5⅜— 5⅝	5⅜	5⅜
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	...	15½— 16½	15½— 16½	16½	16
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	...	14½— 15½	14½— 15½	15⅜	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	5 %	5 %	...	5⅞— 6⅛	5⅞— 6⅛	5⅞	...
1,100,000/	Do. 3½ % Deb. Stock Red.	...	3½%	3½%	...	104 —106	104 —106	104¾	...
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... — ...	... — ...	...	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	4½%	9/16— 11/16	9/16— 11/16	...	...
100,000/	Pacific and European Tel., Ltd 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	106 —109	106 —109	...	...
11,839	Reuter's Ltd.	8	5 %	0 %	*nil*	3½— 4½	3½— 4½	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	124 —129	123 —128	126	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1 — 2	1½— 2½	...	...
146,733/	Do. do. 5 % Debs.	Stock	5 %	5 %	5 %	85 — 90	87 — 92	89	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	..	...	...	4½— 5½	4½— 5½	...	...
238,300/	Do. do. do. 5 % Debs.	100	5 %	5 %	...	102 —105	102 —105	...	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	1½— 2½	1½— 2½	2 3/16	1⅞
150,000/	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	...	100 —105	100 —105	...	...
64,245	Western and Brazilian Teleg., Ltd.	15	2¼%	2¼%	3 %	10½— 10⅝xd	10½— 10⅝	10⅝	10½
33,129	Do. do. do. 5 % Pref. Ord.	7½	5 %	5 %	5 %	6½— 6⅝xd	6½— 6⅝	6½	...
33,129	Do. do. do. Def. Ord.	7½	...	...	1 %	4½— 4⅝xd	4½— 4⅝	4⅝	4⅝
171,900/	Do. do. do. 6 % Debs. "A," 1910	100	6 %	6 %	6 %	103 —107	103 —107	...	...
214,800/	Do. 6 % Mort. Debs., series "B," red. Feb. 1910	100	6 %	6 %	6 %	103 —107	103 —107	...	...
88,321	West India and Panama Teleg., Ltd.	10	⅛%	⅛%	⅛%	⅜— 1	⅜— 1	7/8	⅜
34,563	Do. do. do. 6 % 1st Pref.	10	6 %	6 %	6 %	10 — 10½	9¾— 10½xd	10	9¾
4,669	Do. do. do. 6 % 2nd Pref.	10	6 %	6 %	6 %	8½— 9½	8½— 9½xd	...	...
80,000/	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	5 %	5 %	5 %	110 —113	110 —113	110½	...
$1,211,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds	$1000	7 %	7 %	7 %	113 —118	113 —118	...	...
166,900/	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	101 —103	101 —103	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	5 %	4½%	4½%	5¼— 5⅜	5¼— 5⅜	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	...	5 %	14 — 15	14 — 15	14⅜	...
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	15½— 16	15½— 16	15 15/16	15 3/16
100,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	133 —136	133 —136	...	...
50,000	†Liverpool Electric Supply, all paid	5	5 %	5 %	5½%	7⅜— 7⅞	7⅜— 7⅞	...	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000	10	2 %	2½%	3 %	10¾— 11¼	10¾— 11¼	...	...
100,000/	Do. 5% Deb., bonds of £10, £20, £40	...	5 %	5 %	...	... — ...	... — ...	...	...
150,000/	Do. 4½% first mortgage debenture stock	...	4½%	4½%	...	117 —119	117 —119	119	117
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	1 %	8 — 8½	8 — 8½	8¼	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	7½%	4½%	6½%	8¼— 8⅝	8¼— 8⅝	8⅝	8½
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8¾— 9¼	8¾— 9¼	9 3/16	9⅛
59,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000	5	3½%	4 %	5 %	7¾— 8¼	7¾— 8¼	8	7 15/16

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation, May 29th.	Closing Quotation, June 5th.	Business done during week ended June 5th, 1895. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	6 % §	6 % §	...	2⅜ — 2⅝	2⅜ — 2⅝	2 9/16	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 % §	6 % §	...	2¼ — 2½	2¼ — 2½	2 9/16	2 5/16
125,000*l*	Do. do. 4½ % Deb.	Stock	4½%	4½%	...	113 —116	112 —115	113½	113
630,000*l*	City and South London Railway	Stock	⅝%	⅝%	1½%	44 — 46	44 — 46	...	...
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	7 % §	7 % §	...	2½ — 3	2½ — 3	...	...
50,000*l*	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	5 %	5 %	5 %	... — ...	no quotation	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	*nil*	*nil*	...	¼ — ¾	¼ — ¾	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	...	1¼ — 2	1¼ — 2	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd., 1 to 66,750 ...	2	*nil*	*nil*	...	... — ...	... ...	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	1 — 1¼	1 — 1¼	1⅛	1
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	1⅛ — 1⅜	1⅛ — 1⅜	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	...	¼ — 1½	¼ — 1½	...	...
9,600*l*	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	*nil*	...	6½ — 7½	6½ — 7½	...	...
6,837	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	5 %	6 %	10 — 11	10 — 11	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	10 %	21½ — 22½	21½ — 22½	22⅝	22
200,000*l*	Do. do. do. do. 4½ % Deb., 1896	100	4½%	4½%	4½%	102 —104	102 —104	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	1 %	1½%	9⅝ — 9⅞	9⅞ — 10	10	9 31/32
6,295	† Do. do. Pref., £10 paid	10	...	5 %	5 %	14⅜ — 15¼	14⅜ — 15¼	...	...
	Swan United Electric Light, Ltd.	...	10 % §	7 3/16% §	...	... — ...	... — ...	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	15 %	20 %	20 %	42 — 44	43 — 45	44½	43¾
150,000*l*	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	106 —109	106 —109	...	...
54,000	Waterloo and City Railway, Nos. 1 to 54,000, £2 paid ...	10	...	...	...	2¼ — 2½	2¼ — 2½	2½	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50°/ for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

CROMPTON & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0°/₀§; 1891—7°/₀§; 1890—8°/₀§.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5⅜—6¼.

Electric Construction Corporation, 6 % Debentures, 84—87.

Electric and General Investment, shares of £5 (£1 paid), no market.

House-to-House Company (£5 paid), 4¼—4⅜.

Do. do. 7 % Preference, of £5, 7½—8.

Do. do. 6 % Debentures of £100, 108—110.

Kensington and Knightsbridge Electric Lighting Company, Limited Ordinary Shares £5 (fully paid) 7½—8; 1st Preference Cumulative 6 %, £5 (fully paid), 7—7¼.

Liverpool Electric Supply, £5 (fully paid), 7½—7⅝.

London Electric Supply Corporation, £5 Ordinary, ¼—½.

Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, no market.

Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 5⅜—6¼.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

SINGLE-PHASE ALTERNATE CURRENT MOTORS.*

By A. C. EBORALL.

THE extension of alternate current systems for the distribution of electricity is creating a demand for an alternate current motor capable of running on the ordinary lighting circuits. This demand, though small at present, will undoubtedly increase in the future, and hence the problem of building such motors to be commercially satisfactory becomes of importance. At present this problem cannot be said to have been completely solved, although it has occupied much attention, both in England and abroad. It is the object of this paper to review, as far as possible, what has been done and what has been attained in this direction.

Single-phase motors may be broadly divided into three classes:—

I. Constant magnetic field motors.
II. Alternating " "
III. Rotating " " (split current).

I.—CONSTANT MAGNETIC FIELD MOTORS.

It was early known that any alternator of good construction could be run as a motor if certain conditions were observed, these being—

1. Its field magnet must be excited to a certain degree by a continuous current, and

2. Its rotating part must be run up to a certain speed, corresponding to the frequency of the supply current, before it may be switched in.

Having done this, the rotation will continue synchronously with that of the alternator supplying current to the circuit, no matter what the load, until a limit is reached depending on the size and conditions of working of the machine, which, if exceeded, causes the latter to stop dead. This limit (under proper conditions) is generally about twice its rated output.

If the generator and motor be of similar construction, their speed will be the same—if the number of poles in the two machines differ their speed will vary inversely as the relative number of poles.

For large powers such reversable alternators make splendid motors, as their speed is as regular as that of the alternator supplying current, they require a minimum of attention, owing to the absence, in most cases, of any commutator device, and their efficiency at all loads can be made very high (at full load 90 per cent. commercial efficiency can be safely guaranteed). Another important point is that the power factor of these synchronous motors can be made as high as that of good closed circuit transformers.

But when we come to small powers, motors of this type cannot, as a general rule, be employed, as the complication of exciter, synchroniser, and starting arrangements, and bringing the motor up to speed, preclude their use, though for heavy work, going on continuously, nothing is more suitable than the synchronous motor.

There are two principal ways of starting motors of this description. A method used by the Westinghouse Company in some of their single-phase transmission plants is as follows:—A small self-starting single-phase motor, say of the Tesla type, is provided, together with the necessary clutches, and then the operation of bringing the synchronous motor up to speed is thus:—

The Tesla motor is switched on the alternate current mains, and when it has got up speed, is clutched to the rotating part of the synchronous motor, thus rotating the latter, together with its exciter. When a speed rather above the normal is attained, and an exciting current in proportion, the Tesla motor is unclutched. The speed of the synchronous motor then gradually falls, and at the right moment, indicated by a synchroniser, the main switch to the motor is closed, the latter then pulling itself in. The load can then be transferred from the loose pulley to the motor pulley. The clutch for the Tesla motor sometimes consists of two friction discs, one on the shaft of the latter, the other on the shaft of the synchronous motor, these being brought into gear when required by sliding the Tesla motor along the bed-plate.

The other method referred to, due to Mr. Mordey, is as follows:—The exciter, which is coupled direct to the motor shaft, is used in conjunction with a storage battery, which need only be capable, however, of giving a heavy discharge for a few minutes. The storage battery is used to excite the field magnets, and to drive the exciter as a direct current motor, thus bringing the revolving part of the alternate current motor up to the required speed. When this is attained, as indicated by the synchroniser, the alternate current is switched on the motor, which then gets into step, and runs the exciter as a direct current dynamo, thus recharging the battery and exciting the fields at the same time.

A modification of this method is used to start the large synchronous motors driving continuous current dynamos supplying power to the town of Cassel.

Other ways of starting synchronous motors have been suggested by Mr. Tesla, depending on the production of a rotating field in the armature of the motor, which is destroyed when the latter has

* Read at a Student's Meeting, Institution of Electrical Engineers, May 3rd.

attained synchronism. The field magnets, previously short-circuited, are then switched on the exciter, and the line current switched on the motor armature, which then gets into step. I do not know whether this method has been employed in practice—it would probably only answer at low frequencies.

In order to get the best results from these synchronous alternate current motors, certain conditions must be observed in working. It has been found that for a given load on the motor, there is always a certain definite value of exciting current that will make the armature current a minimum. This is well shown by the curve given in fig. 1, due to Mr. Mordey, showing the dependence of the armature current on the excitation.

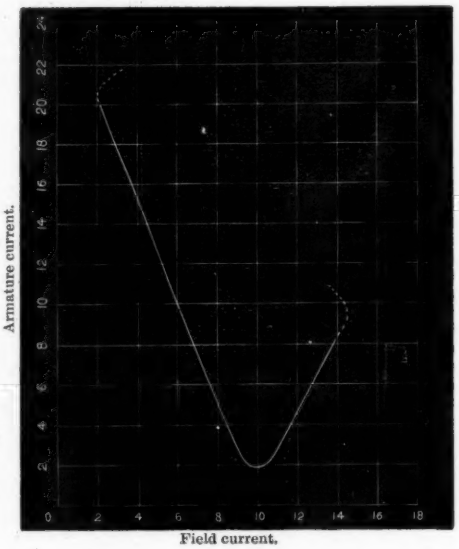


FIG. 1.

It relates to a 25-kilowatt alternator run as a motor, at no load. The general shape of the curve is that of the letter V. Running light, as shown here, the lower part of the V is very acute, but it gets rounder, and the whole curve broader, as the load increases. It will be seen that its lowest point corresponds to the state of affairs when the field current having a certain value, the armature takes a certain minimum amount of current from the mains to do the required work at the given speed. If the field current be altered above or below this value, an increase in the armature current takes place, though the motor is still doing the same amount of work at the same speed.

Dr. S. P. Thompson has shown that the motor armature takes a minimum current from the mains when the pressure and current are in phase—that under-excitation causes the armature current to lag and over-excitation to lead. This is, perhaps, more clearly seen in a numerical example.

Take the case of a 25 kilowatt machine working on 2,000-volt mains. Such a machine might have an armature resistance of 3 ohms. Further, suppose it was found that the minimum armature current required to drive the load was 12 ampères.

It would be found that the excitation corresponding to this minimum armature current would be such as to generate a back E.M.F. of about 1,960 volts, for

$$\frac{2{,}000 - 1{,}960}{3} = 12 \text{ ampères (approximately)},$$

which is the current required by Ohm's law, and corresponding to the condition of no lag or lead of the armature current.

But suppose now that the excitation is decreased. The load is still driven at the same speed, but the back E.M.F. of the motor has fallen, on account of diminished excitation. Suppose it has fallen to 1,900 volts. Now

$$\frac{2{,}000 - 1{,}900}{3} = 30 \text{ ampères (approximately)},$$

and whereas before 12 ampères at 1,960 volts was sufficient to drive the load, the motor now takes 30 ampères at 1,900 volts. Now this current is far in excess of what is wanted for the load, and as a consequence it is choked down to such a value that this 30 ampères × 1,900 × cosine of the angle of lag, is equal to 1,960 × 12, the product of the original volts and ampères. So if the motor be under-excited it acts like a choking coil, producing an idle current which does nothing except waste energy in heat in line and motor.

If the motor had been over excited—let us say to such an extent as to produce a back E.M.F. of 2,000 volts, then

$$\frac{2{,}000 - 2{,}000}{3} = 0,$$

and there would be no current unless its phase adjusted itself to suit. Instead of the current dropping to zero, more than before comes into play, and the maximum values of this current occur before those of the impressed E.M.F. thus producing a lead, the under-excited synchronous motor acting like a condenser.

In this case also, there is a wasteful idle current—it is also apparent from the above why it is that it is perfectly possible to run a motor of this description giving a back E.M.F. greater than that of the generator.

Dr. S. P. Thompson early pointed out that such over-excited synchronous motors should prove of great value in alternate current networks, to compensate for the inductive drop in the mains due to transformers or other motors. I believe that such "phase rectifiers" have been used for this purpose with success, both on the Continent and in America.

This V curve also tells us when the motor will pull up with any given load, the excitation being varied. In fig. 1, it will be seen that if the exciting current be decreased to two ampères, no further increase in the armature current takes place, but the curve turns in. At this point the machine gets out of step with the generator and pulls up. Similarly, if it be increased to 14·5 ampères, anything more will cause the machine to pull up, as the curve would be missed altogether.

The question arises—at what point on the V curve is it best to work? Theoretically, it would be best to work at its lowest point, as then the power factor and efficiency of line and motor would be a maximum. But insomuch as in most transmission lines there is a considerable voltage drop due to resistance, self-induction, &c., in generators, line, and motors, it is found better to depart somewhat from the theoretical conditions. Armature reaction in generator and motor must also be taken into account. It appears that, using motors with a small and negligible amount of self-induction and resistance, that the motor will take a bigger load without pulling up if the fields are somewhat under-excited, that is, that the back E.M.F. of the motor be less than the impressed E.M.F. of the generator.

On the other hand, if there be much self-induction, resistance, or armature reaction in the motor, the latter would probably work best if somewhat over-excited, that is, that its back E.M.F. be higher than the impressed E.M.F. of the generator by a certain small amount.

The minimum excitation needed is generally different with different loads on the motor. Sometimes at full load more excitation is needed, sometimes less. It depends to a large extent on the design of the motor. If the armature reaction exactly compensates for the loss by armature impedance, the best excitation would probably be the same for all loads.

But no definite rule can be given for this question of "best excitation." It is different for every case occurring in practice, and for different designs of plant, and experience has to be the only guide in determining the best working conditions for any particular case.

There are very few alternators capable of running as motors on the English market in small sizes at the present time. However, Messrs. Pyke & Harris make such small alternators in sizes of from 2 to 10 H.P., extremely suitable as synchronous motors for use in situations where the bringing of the motor up to speed is not a serious objection. These motors (which have no rubbing contacts of any kind, and whose rotating part consists simply of laminated masses of iron) will get into step at a half synchronous speed, and a recent test of a 6 unit machine running as a motor showed an apparent efficiency of 65 per cent. The commercial efficiency would be considerably higher than this—the efficiency of such a machine running as a generator is about 93 per cent.

(To be continued.)

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

DISCUSSION ON MR. MARK ROBINSON'S PAPER.

(*Concluded from page* 680.)

Mr. WRIGHT,* who was called upon by the chairman, said he was afraid his remarks would be uninteresting as he had nothing but compliments to offer. He had had about 2,000 H.P. of these engines under his control and had had no bad experience whatever. The whole of that 2,000 H.P. was managed by two men and a boy. He had hardly ever seen the insides of the engines, and had had no bother with them of any kind. Results showed that, so far as economy was concerned, they at Brighton could achieve it as well as other people. He could not imagine a better engine.

Mr. DRUITT HALPIN* said at the last meeting they heard some very high figures indeed about brake efficiency. He had never had one of these single-acting enclosed engines on the brake and knew nothing at all about their efficiency. But they heard a good deal about the common or garden engines running into fabulous efficiencies, 91, 92, and 94 per cent., and he certainly could not believe any figures of that kind unless he was given means of verifying the statements made. They knew there was nothing that would lie more consistently than an indicator, except, of course, a voltmeter or an ammeter. It was also known that it was very possible to get wrong indications in the brake. There was great trouble and scandal some years ago about the question of brakes, and it was shown then that the brakes were all wrong and all the results got from them were wrong. He would tell them one thing that made him sceptical about those high efficiencies. He saw a small engine braking 30 or 40 H.P. running empty, just turning round in steam, warm; it was running pretty freely, because three men, big powerful men, separately took hold of the fly-wheel and shoved it round to see what they could do. One of them by superior strength or skill after he had let the wheel go got three revolutions out of her, so there was not much wrong with that engine so far as friction went. It was about as free from friction as they could get an engine. That engine on careful braking and indicating could only just get a bare 90. He had once seen a small fraction more, but only once. The remarks of the last speaker about the oiling and the necessity of having reversal of stress at the end of the stroke, change of stress, to enable the engine

* Speakers to whose names an asterisk is attached have corrected their remarks.

to run, reminded him of a discussion he had with M. Belpaire, Director-General of the Belgian Railways. His view was that all railway travelling would be impossible simply on the ground of lubrication if it were not for the slight tremors produced by the road allowing the lubrication to get in; else the whole thing would stop and no system of lubrication could be maintained. But he certainly could not agree with the last speaker that it was necessary to have this perfect reversal of stress to get lubrication in. He had read Mr. Siemens's paper about the results of the double-acting engine with very great interest, but he must say for himself he did not see, for continuous high-speed, even with the forced lubrication system in use, how they were going to get continuous running in spite of all the good workmanship.

Mr. Geipel* said the paper which Mr. Robinson had put before them bristled with information on points which were of the utmost interest to practical electrical engineers. The thoroughness which the various parts were dealt with indicated the energetic management at Thames Ditton, which most of them were aware had contributed so largely to the success of the Willans engine. There were one or two points in the paper, however, to which he would refer, with a view to obtaining even more information from the author than he had already given. In the first place, in speaking of the costliness of slow-speed direct-driven steam dynamos, he took it Mr. Robinson referred only to first cost; otherwise was it not somewhat previous to state that high-speed would last as long as slow-speed engines? They knew that there were slow-speed engines which had been at work for 42 years and upwards which were running at the present day; that the Willans or any other high-speed engine would do this had yet to be proved. If they would not last so long then it was necessary to take into consideration whether the earlier renewal of the one would balance the increased first cost of the other. They all knew how seriously the cost of electric supply was increased by the lying idle of so large a fraction of the plant as was necessary to meet the two short periods of heavy load, and if there was a doubt as to the lasting powers of high-speed engines, when worked continuously, might it not be advantageous to combine the two systems so that slow-speed engines were used for the light loads while high-speed engines were used for that part of the plant which was chiefly idle, the first cost of which, owing to its being so large a fraction of the whole, was so important a factor in the cost of supply? For that part of the plant durability would be less important, of course, owing to the comparatively few hours of use per annum. Mr. Robinson referred to the difficulty of overcoming the vibration so far as concerned the one and two-crank engines, and recommended the three-crank double engine. This, of course, was not a question which greatly concerned the users of high-tension systems, who could generally put their engines in distant places where vibration was of little moment. But was not the method of overcoming the vibration advocated a further argument in favour of the use of slow-speed for the light load engines? For he doubted if Mr. Robinson himself would advocate the use of two engines, each having nine cylinders, that is 18 cylinders in all, for the purposes of driving the light loads. For tramway work the author correctly emphasised the necessity of engines considerably larger than were required for the mean power, and, in paragraph 23, he referred to the higher mechanical efficiency of double-acting engines at light loads. He agreed with the author in that, and believed that for such work the double-acting engine was best, at least in that respect. The necessity of using powerful governors and giving them next to nothing to do, mentioned in paragraph 49, could not be too strenuously dwelt on. The makers of throttle-valve governors were too prone to cut down the weight of the balls. Not many weeks ago he had occasion to write to a firm who made governors in large quantities to put larger balls on a particular governor that they had supplied, and which could not be made to work without hunting. It would be almost incredible to them when he told them that they seriously proposed to increase the size of the throttling valve in order to obviate the hunting. There was no part in an electric light engine which was more important, and to which probably less attention had been paid hitherto than the governor. He agreed with the author as to the desirability of using plenty of fly-wheel power to control the engine in the event of sudden variations in the load, though he did not believe that the fly-wheel had so much steadying effect on the governor as he stated; in fact, if there was any undue friction in the governor it was conceivable that the jerky rotation due to a light fly-wheel would assist the balls in overcoming any extra friction which might otherwise cause hunting. The great sensitiveness of shaft governors was, in his opinion, partly attributable to a continual variation in the strains on the parts controlled by the balls; probably at certain moments in each revolution there was comparative absence of friction, so that the balls were free to move the eccentric to its proper position; anyhow, speaking from experience, he had found shaft governors, notwithstanding the heavy work entailed on the balls, to give closer governing than throttle-valve governors.

Mr. J. N. Shoolbred* said there were one or two points in this very valuable and interesting paper which he would like to remark upon, having himself had the advantage of seeing the working of these engines from time to time for some period. There was one point with which he would commence in regard to which he was afraid he could not eulogise the engine in the same way that Mr. Wright had done. A point raised in the paper and spoken of lately and treated before the Institution of Mechanical Engineers, that was the question of expansion *versus* throttling valves. It had seemed to him to be a blemish on the Willans engine—the use of the throttle valve. To use it economically it was necessary to keep it pretty fully loaded, and it had not the advantage of the double-acting engine in respect to the expansion valve; and it seemed rather contrary to one's ordinary ideas that the steam at a very high pressure should be throttled down and made use of at a loss of 25 per cent., or perhaps even 75 per cent. of its pressure. That in itself seemed an anomaly. Of course, the great remedy lay in keeping the engines as fully loaded as possible. There were several arrangements whereby the engines, and notably Willans engines, had been enabled to be worked pretty well up to their mark in central stations. Such as choosing various sizes of engines to relieve one another when increasing, or diminishing the load; so as to ensure the engines always being loaded from at least 75 per cent. to full load. Then again there came in a very valuable adjunct in the form of accumulators. He had heard a good deal lately of the mode of procedure in a small station at Pontypool, South Wales. Accumulators were made use of there to supplement the engines and to keep up as far as possible a maximum load. This was not only a very interesting experiment, but apparently had been very successful in effecting the utmost economy in the engines. Of course, against that there remained to be seen how much practically they were paying for that economy in the cost of the accumulators, which might be of a good type or of a poor type. That he would not enter into at the present moment; but it seemed to him that was one means of ensuring the success of a throttle valve engine like the Willans engine. There were many points in which the Willans engine in itself certainly seemed to be more satisfactory in working than double-acting engines, at all events in such cases where he had had the opportunity of comparing with the Willans engine, double-acting vertical engines by recognised good makers. There was no question as to the value of the Willans engine, as regards steadiness, quietness, silence in working, or as to absence of vibration. The Willans engine was spoken of as the engine of the future; he would rather look at it as the engine of the present. He thought as they got into larger powers the more would the double-acting engine be used, even more than the Willans. At the present moment for 50 H.P. and 300 H.P. up to 500 H.P., the Willans, being only single-acting, did not become excessively small, as would the pistons and various valves of a double-acting engine. But, once they got beyond that size, double-acting engines came very much to the fore. He had gathered in discussions with persons who had a greater practical knowledge of engines than himself, they admitted that below that limit the Willans engine had a superiority, but above it, up to 1,000 H.P. or more, the vertical double-acting engine would prove to be the more successful. What might be the case in the future beyond that he could not, of course, pretend to say. But in any case, whatever the merits or otherwise of the Willans engine, they must all admit it had rendered during the early days of electric lighting a valuable service to them all. It had filled the gap which remained when they found themselves at the end of the tether of the agricultural engine, the first that helped them over the difficulty before they got central station lighting; as soon as central station lighting was reached, the Willans engine fulfilled the conditions in a way which no other engine could then have done, and whatever its merits or demerits they must be exceedingly thankful to the ingenuity of the late Mr. Willans.

Mr. R. W. Allen said, as a designer of double-acting engines for some years, he would like to give Messrs. Willans & Robinson credit for setting them a lead, not only in the designs of double-acting engines, but also in the excellence of manufacture, which was a most important point. He would lay stress on the crank shaft, which was the basis of an engine. There were very few men who could really turn a crank shaft which was true; and unless the crank shaft pin was true trouble would certainly take place. With regard to what Mr. Malcolm had said, no doubt when he designed his engine, like his firm themselves had done with theirs, he had had the section of a Willans engine in front of him and had taken advantage of the 15 years' experience of Messrs. Willans & Robinson, which had not only helped them but the world at large, the designers of small and large engines. No doubt what Mr. Morcom had said was true with regard to the engines in the Navy; but that was, of course, due to circumstances over which Messrs. Willans & Robinson had no control. He could give an instance of the way in which one of his firm's double-acting engines had been treated on a ship which had been lying up in port for a few days. Water had accumulated in the steam pipe, and the engines were working at full loads; this was the night before sailing. The engineers turned on the wrong cock, and, instead of the water going to the condenser, it came right back to the engine and the engines were doubled up. That would take place with a single-acting engine just the same as with a double-acting engine. He had only seen the death of a Willans engine once and then certainly its parts were swept up in a dustpan. But there was no doubt that since the strengthening of the crank shaft the Willans engine had become one of the most perfect of philosophical instruments and one of the most scientific engines of the day.

Mr. R. Dumas* said although he had had nothing to do with central station lighting he had had a little to do with the Willans engines on board Her Majesty's ships, and as far as his experience was concerned the interchangeable system of manufacture employed at the Willans works was found to be a very great advantage. The author of this admirable paper had gone so fully into the difficulties, the successes, and improvements of the engine dealt with that he had, to a great extent, forestalled discussion. There were, however, some points to which he should like to call attention and in regard to which he would ask for further information. Taking the three points to which special attention was directed in the order in which they were given at the end of paragraph 11, he would first make a few remarks about the packing rings. With reference to the piston rings it was rather surprising to find that steam packing had been so successful, since it had been tried and abandoned by so many others; the only conclusion one could come to was that some essential point had been overlooked in previous designs. With the piston rings exposed to the varying pressure of steam in the cylinder it might be expected in cases where the lubrication was not efficient that the wear in the upper part of the cylinder would exceed the wear in the lower part. Perhaps Mr. Robinson in his reply would

be able to tell them whether he had come across any such cases. That the amount of lubrication had an important bearing on the case was evident from the laws of the transmission of pressure in fluids, and from paragraph 13, where it was stated that with the old design of rings, they could be started collapsing by increasing the oil supply. With an ample supply of oil it was probable that no variation in the wear of the different parts of the cylinder would be found. With regard to the piston valve packing it would be interesting to know if any experiments had been made with a view to ascertaining the steam pressure in the interior of the valve; probably it was not far from a mean between the initial and exhaust pressures. Assuming this to be the case, it seemed evident that collapsing of the rings of the upper part of the valve must take place in consequence of the excess of the outside pressure, and this especially when the packing rings came opposite the ports. The lower rings on the contrary must be pressed somewhat severely against the valve trunk, as with them the inside pressure exceeded the outside Probably, therefore, the wear in the lower part of the valve trunk was greater than in the upper part. Doubtless Mr. Robinson's experience was sufficient to set this point at rest. He supposed the reason why no attempt had been made to subdivide the hollow valve was that the weight would be increased thereby, and this would increase the difficulties mentioned in the paper in the case of throttling engines working on light loads. With regard to the internal drainage, the coning of the pistons was at once a simple and efficient way of overcoming the difficulty as far as the cylinders were concerned, and it was a most happy coincidence that the strength of the pistons was increased at the same time. One had only to suppose the coning of the piston to be of the opposite sense to that adopted in order to appreciate the superiority of the latter. In the one case the piston would act most efficiently in doing the very thing to be avoided, namely, in spreading a thin film of moisture on the cylinder walls, while with the piston coned down at the centre, the moisture disappeared down the valve trunk. With regard to the Cornish cycle he was of opinion that that was a most important and beneficial feature in the engine. He was rather surprised to hear Mr. Tremlett Carter question its advantages; probably, however, he had, after perusing the paper at leisure, altered his opinion. With regard to the air-cushioning arrangement, he understood that this was so designed as to keep the lines of parts (of course, excepting the line of valves) in constant thrust even when there was practically no pressure in the steam chest. This being so, it was clear that whatever effective pressure there was in the cylinders was added to the pressure due to the air-cushion, and that the pressure on the crank pin must be very severe during some parts of the down stroke. Probably this had some connection with the crank-shaft breakages referred to in the paper. Since there was so little clearance, and, consequently, compression in a Willans engine, the valve trunk must for some parts of the up-stroke be in tension. He would like to know if there had been any trouble with breakages through the bottom row of ports. Doubtless the air-cushioning arrangement was very efficient, and was more easily adjusted than the compression in a steam cylinder. In a double-acting engine the compression curve was often very deceptive, especially when the diagrams from the two ends of the cylinder were separated. Now that variable expansion had in some cases been adopted, and that the full pressure was available on the high pressure piston for acceleration of the parts, there seemed to be no reason why an effort should not be made to get rid of the air-cushioning cylinder. This could be done by arranging for the valve itself to cut off about ·6 of the stroke, release to take place at ·9, and compression about ·83. Naturally the clearance volume and consequently surface would have to be increased; if it was objected that this would prejudicially affect the economy of the engine he would ask what had been the effect of letting steam to the back of the piston rings, and thus considerably to increase the clearance surface? He was of opinion that the mechanical efficiency of the engine would be sensibly increased if the cushioning cylinder could be dispensed with. He was aware that this would not be possible if a late cut-off were required, as sufficient compression could not be obtained in the steam cylinder. The remarks in the appendix on the subject of jacketing were very interesting. It would add considerably to the value of the paper if the percentage of steam condensed in the jackets in the case referred to could be given, and Messrs. Willans & Robinson would earn the gratitude of engineers if a series of trials were made on the same engine to show the effect of jacketing on steam consumption over a wide range of revolutions when exerting the same torque.

Mr. Head* said he had not had an opportunity of reading the paper, and he was not a member of the Institution, but the President and Council had been kind enough to invite him to speak. The point which had struck him most in the exceedingly interesting discussion which had taken place was that raised by Mr. Morcom about the difference in lubrication as between a single-acting and a double-acting engine. It might be of some slight interest to the meeting to know that a good many years ago he was so smitten with that beautiful piece of mechanism, the Brotherhood engine, that, after purchasing several of them, he determined to have one made that should be larger than any that had ever been made before. Accordingly he had one made with 20-inch cylinders, to work with a pressure of 60 lbs. to the square inch above the atmosphere. This engine was put to drive a rolling mill, and it ran at 300 revolutions per minute; but he was sorry to say that it utterly failed in the end by the seizing of the crank pin. Very elaborate arrangements were made for oiling that crank pin, the oil was not pumped in, it was merely allowed to run down the vertical piston rod and connecting rod with a considerable hydraulic head upon it. As he had said, it failed because the connecting rod ends continually seized the crank pin and pulled the engine up. That impressed him very strongly with the view that single-acting engines, which were always bearing on one side only of the journals, were liable to fail unless some arrangement was made by which the oil could be pumped in at a pressure at least equal to that upon the surfaces. He thought that little bit of information might be considered to bear on the subject and be of interest to the meeting.

The President* said, in bringing the discussion to a close, he wished to say a few words, because he had had the honour and pleasure of being a very intimate friend of the late Mr. Willans, and because he was one of the first people who bought one of his engines. It was 19 years since he first bought a Willans engine, and he had been using Willans engines during the whole period of time which had since elapsed. He thought that this paper, which was on the subject of high-speed engines, had been unfairly criticised in one technical journal. It had been said of Mr. Robinson that he used his opportunity in discussing high-speed engines to discuss the Willans engine only. Everyone in that room, he thought, would agree with him that the paper itself was a complete reply to that suggestion. It was perfectly reasonable that a member of the firm of Willans & Robinson, who had made such an enormous number of high-speed engines, should give the results of his own experience more than those of other firms. They would not have welcomed his paper so warmly if he had given them hearsay evidence. He had given them his own experience, and that was the thing that was most valuable to them. That was enough on that point. He (the speaker) had had over 25 years' experience in direct charge of steam engines, and of the earlier part of that time he had very unpleasant recollections. He was then out in India, and had to let the brasses together himself very frequently, because native labour was then untaught; so that he of all men could appreciate the difficulty of keeping double acting engines in order, in eliminating troubles connected with the bearings, and in keeping the engines free from knocking and vibration. It was his strong feelings on that point which brought him in very early association, first with Mr. Brotherhood, whose name had not been sufficiently mentioned in this discussion, and subsequently with Mr. Willans. He was sure the firm of Willans & Robinson would be the first to acknowledge the great services which Mr. Brotherhood had rendered to the cause of high speed engines. He would not touch those points in the discussion, which would be dealt with more completely by Mr. Robinson. He (the president) did not speak at all as an advocate of the Willans engine *qua* Willans engine, but he did speak of it from the point of view of regarding it as a highly successful high speed engine, and he did so because high speed had been the making of electrical engineers, for if high speed engines had not been introduced they would not have made such progress with their central station work as they had done. He thought Mr. Morcom and Mr. Chandler would agree with him in what he had said on that point, that the great trade that had been made, and was likely yet to be made, in high speed engines, owed a very great deal to the Thames Ditton firm. Mr. Raworth, in his very humorous speech, objected to the Willans engine because it was such a puzzle to put together. He (the president) must say that he did not understand this statement. He was in charge of a great many of these engines, and had always found that they were taken down and put together by labour much more unskilled than that usually employed in such cases, by men who were not fitters in the usual sense of the word, and who would not be trusted to fit together the brasses and other work of that kind in an ordinary double acting engine. The reason was that in the Willans engine all they had to do was to take it to pieces and put it together again in just the same way, and if the parts were worn, to put in others of the same kind. The work was perfectly simple, and the men had only to obey orders. It was not fair of Mr. Raworth to talk of the large number of parts in the Willans engine. He compared the engine he used, an ordinary side by side marine compound with a compound or triple-expansion Willans engine, which had an extra number of cylinders because Mr. Willans found it of greater advantage to arrange his expanding cylinders tandem fashion, as he could not get an equal turning moment throughout the stroke with a side-by-side arrangement. He (the speaker) was the purchaser of a side-by-side Willans compound engine in 1879, and he exhibited it at the Kilburn show. That was quite as simple as any ordinary compound side-by-side engine, and had as few parts; but he (the speaker) had long talks with Mr. Willans, and pointed out that they must work their engines through large ranges of rate, and the turning moment must be equal throughout the stroke. This did away with the force of the comparison, which would otherwise have been a fair one to make. Mr. Raworth told them a most interesting story about a dynamo, a tramcar, and a horse. In his comparison between the complication of the motor of a tramcar and the inside of a horse, he hit upon the real reason why many engineers, including himself, thought that Mr. Willans and other engineers who enclosed their engines had done the right thing. What mattered it that parts were complicated, if it was found in practice that they were very effective, and did not become deranged. The constructor of the horse was well aware of this; he knew the horse was as simple a machine as could be devised for the purpose, but knew also that people would object to see the working parts, and also knew that the lubrication, and things of that sort, were not nice things to be flying about in public, and therefore he encased them. He thought that was a sufficient justification for Mr. Morcom and Mr. Chandler for enclosing their engines in the way they had done, and they did not mind their complicated insides, so long as the steam went in and the power came out, and they did not want repairing. He would give them another illustration. He was sure the mechanical engineers present would agree that the practice of Continental engineers in putting all the working parts of their engines outside was positively indecent. He thought that in closing in their engine works as the firm of Willans & Robinson and others had done, they had rendered the same good service as had the makers of the Great Northern and other locomotives in this country, in comparison with the Chemin de Fer du Ouest, whose locomotives were before their eyes when they landed at Havre or Dieppe. The opponents of

high speed engines were always telling them that if they wanted the highest economy, combined with the highest stability, they must adopt Lancashire practice; they must use large slow speed engines; and they were flooded with leading articles in the technical journals to the effect that they, electrical engineers, ought to take lessons from the fountain head in reference to engines. He had challenged all the fountain-head men to come there, and he could not get any of them to speak. Apparently they had nothing to say, or they would back up the articles that had been brought forward. But there could be no doubt that their outcry had influenced—and he regretted it very much—a number of the members of their profession, for engines were still being put in in a way which was really pandering to this outcry. This, he was sure, would be a cause of regret to the users of those engines, when they compared their results with the results obtained by those who used high speed engines in their central stations. He believed all the speakers that evening were in agreement on that point. He regretted that they had not some of the enemy present there that evening. No doubts were so frequently raised as those regarding the durability and the cost of repairs of high speed engines. Eight or nine years ago it was found that in central station work the cost of repairs was as little for high speed engines as for low speed, and in some cases it was even lower. They were getting rather tired of hearing these objections, and he would like to hear something fresh; he would like to hear upon what grounds those assertions were being made. He regretted to hear one gentleman speaking of sweeping up the interior of an engine in a dustpan; he did not think that was a nice way of putting it. No doubt such things had been, and it was not to be wondered at, seeing the brutal way in which engines were treated in the Royal Navy, where they injected steam pipes full of water suddenly into the cylinders of the engine. It was far better that something should give way, and that a nasty accident should not take place. But there was very little doubt that such accidents did not occur now; any engineer who allowed them to occur in his station would not confess it, because he would know that his experience was so abnormal that he would rather not be thought of as the extremely careless man he would prove himself to be by permitting such accidents. To give them some idea of how unfair were some of the criticisms raised, he might say that he had noticed in an article in a technical paper that came out quite recently that the engines now under discussion were abused on the ground that Mr. G. M. Clark, in those highly interesting figures which he had given, had stated that the consumption was 46 lbs. in practice, whereas it was only 32 lbs. in the test. Well, now, Mr. Clark absolutely proved the reverse of that—that the difference between 32 lbs. and 46 lbs. was all to be explained by causes outside the engine, with the exception of the quantity due to the change of the load factor of the engine. Mr. Clark actually reproduced the identical figures he (the President) had given in his Civil Engineers' paper four years ago, which showed that their figures at South Kensington were the same as were found in test; Mr. Clark, who was a most careful observer, reproduced that very interesting table before the Mechanical Engineers, and which had been copied into Mr. Robinson's paper. Yet the leader writer took that as a proof that the engine efficiency fell off from 32 to 46 lbs. He did think they had every reason to be extremely proud of what the Thames Ditton firm, and of what Messrs. Belliss and Chandler and the other makers of high-speed engines had done for them. They had enabled them to show figures, steam into electrical units, which were better than any other figures he had come across. He sent out a specification the other day for machinery to be competed for by firms other than his own, and he thought the figures in all cases were very close, nearly as good as the figures shown on the table by Messrs. Belliss. Not only were they prepared to deliver the machinery to work up to that high standard of economy, but they were prepared to guarantee it for a year, and not to have the whole of their money until they had proved their figures. He had had a Continental engineer of high repute over here for some time past, and he would hardly credit him when he showed him that specification. He said:—"You will never get it! If you can tell me you can get such a high duty as you specify guaranteed by a first-class firm, I am converted at once to English practice." That gentleman was out of town for a few days, but when he returned he hoped to be able to convince him. The improvements in engine construction had been a very great movement in advance for the benefit of engineering generally, and for electrical engineering in particular; and for that reason he was extremely pleased that the last paper of the session was upon so interesting a subject.

Mr. Robinson,* in replying, said Mr. Raworth rather suggested that he might have treated of other single-acting engines than the Willans. The answer to that was to be found in the title of the paper, which was "Recent Developments in High Speed Engines for Central Station Work." He had confined himself to improvements in the Willans engine, carried out either shortly before or shortly after Mr. Willans's death. If he had dealt with no other engines, it was because none had taken, so far as he knew, a prominent part in central station work. In America there was the Westinghouse, of course; but he had not thought it necessary to deal with that. He had tried to make the paper as general as he could. It would be but affectation to ignore the fact that the single-acting engine in central station work was, for the present, the Willans engine, and in that fact lay the chief reason why he was speaking to them upon the subject. As regards the horse-power in use he knew how difficult it was to get accurate figures. He had taken a published list, which excluded a large unfinished station, probably knocking a great deal off the Brush figures, and at least an equal amount off those for the Willans engine, and he had excluded many thousands of horse-power of the latter which did not, in his judgment, come under the head of central station work for public lighting. Mr. Raworth had said that the engine was such a Chinese puzzle; it was all boxed in. He (the speaker) never could sufficiently admire the virtuous disapproval of many engineers for parts which were "boxed in." Mr. Raworth did not object to enclosing the cranks and connecting rods: it must be the other parts he objected to. Well, he had long been looking out for the engines whose pistons should be outside the cylinders, and whose valves should not be in some sort of valve box; but in vain. You still had to undo nuts to get at things. No doubt this was so in the Willans engine also, but there was evidence in the paper that if you wanted to get at its inside you need not be long about it. He was afraid he had not been sufficiently clear about the connection between high speed and constant thrust. Constant thrust enabled them to run an engine continuously with no knock and very little wear, even at high speeds. With regard to the difficulty with the constant thrust bearings in a Mordey alternator, if there was really such trouble under the very low pressures referred to, he thought the cause should be sought elsewhere than in the nature of the bearing. He had had similar difficulty with bearings apparently quite lightly loaded, where the shafts had (by leakage) formed part of a magnetic circuit, and the conclusion they came to was that such a bearing might appear to be lightly loaded, and yet for magnetic reasons, it might be very heavily loaded. Mr. Raworth had given himself and his colleagues credit for the recent improvements in the Willans engine. But those improvements had either been planned by Mr. Willans, or based upon experiments which he planned and carried out, the only exception being the automatic expansion gear now used. Mr. Chandler had spoken of the valve rings not being steam-packed, and said their engines were in the same case. He certainly would have referred to the Chandler engine in the paper if he had been in possession of facts about it, but not very much had been published as to the economical results obtained with it; he was, however, glad of the opportunity of saying that all he had ever heard of the Chandler engine was very much in its favour. Mr. Morcom had shifted the discussion very much into the nature of a duel between single-acting and double-acting engines, and that was fair enough, because the paper was in praise of the former principle. Mr. Morcom said his firm had made engines running at very high speeds for more than 30 years; he presumed that was for marine purposes.

Mr. Morcom: The large majority have been marine engines, large yacht engines, pinnace engines, and so on.

Mr. Robinson: Mr. Morcom had also referred to Admiralty troubles with the Willans engine, and Mr. Dumas had also referred to that matter. That was a large subject, and he should very much like to enter upon it, but the hour was too late. He could say a good deal about it, and a good deal would have been said but for Mr. Willans's lamentable death. Water in the pipes in excessive quantities, was at the root of the early troubles in the Navy, and he was afraid he had once caused some indignation at the Admiralty by telling them that the Willans engine was intended to be used as a steam engine and not as a hydraulic engine. He had once gone on board a ship in which their engines were used, and when he got to the dynamo room he heard a tremendous noise; one of the engines was pounding away most furiously, and it was a wonder to him that it had not come to pieces. He asked, Was not that engine very noisy? No; they did not think so. He looked for the cause of the noise, and found it. There were air relief cocks fixed to destroy the air cushioning at starting, and, of course, meant to be shut at all other times. With the very best intentions they had taken these for drains, and had coupled them to drain pipes, and then set them open, so that the engines worked without any cushion at all. Of course this was a long time ago. The subject was a large one, and it was not necessary to go into it then. It was news to him to hear that the Willans engines had been taken out on a large scale, and he fancied if this were really the case they were the people who would hear of it. Reference had been made to the breakage of pistons. That was rather a curious point. The pistons were, no doubt, originally designed light, and there were repeated breakages of pistons in the Navy (from water), but the odd thing was, that in few cases did inconvenience result. The broken piston tumbled down to the bottom of the cylinder, and stayed there until the next quarterly inspection revealed them. The engines were of course tandem engines, and whether the high pressure piston was broken down by water from the steam pipes or the low pressure piston was broken by water from the exhaust pipes, one of the two was still left, and continued to run the engine successfully. Mr. Morcom, in comparing single with double-acting engines, said there must of course be a double area of piston and cooling surface, and double stresses on the pins in the single-acting engine. That, of course, was true, if they were to run at the same speed, but there was the crux of the whole question. He believed you could not run double-acting engines permanently and continuously at the same speed. That was the point to be threshed out between the two systems. Mr. Morcom attached importance to the play of the crank pin in its brasses, or the shaft in its brasses, for letting oil in underneath. No doubt the double-acting engine had a theoretical advantage in that respect, but it was only one point out of many affecting wear, and with over 100,000 H.P. of Willans engines at work, they had scarcely ever been troubled with bearings. Mr. Morcom referred also to economy. The economy in the St. Pancras figures was good, but he did not think it was quite correct to say they were the same as for single acting engines working under like conditions. Still it was a very good economy and a very good efficiency. Owing to the uncertainty of measurements, and especially in commercial engine rooms, he was always a little shy of quoting extreme figures. Thus the highest of the efficiencies given by Mr. Morcom just about corresponded with what had been occasionally obtained at Thames Ditton, but they had said very little about it; in fact, they would scarcely believe it unless frequently repeated. With regard to governing, he would remark that the double-acting engine with two cranks was in the same position as a single acting engine with two cranks, as regards number of impulses per minute, because two always occurred at the same time. Governing was of no interest in this connection, because there was no imaginable reason

why the Belliss engine should not be governed as well as the Willans or any other. He thought Mr. Morcom might feel very well satisfied with his answer; it was a good fighting speech, and just the sort of criticism he had wished his paper to produce. Mr. Halpin's remarks on the helpfulness of the tremor on the lubrication of the brasses were very interesting. Mr. Geipel asked how long the engines would last: would they last 42 years? It would take him nearly 30 years, unfortunately, to answer that question. So far as the shell of the engine went, he did not see why it should not last for ever, and from the report of Mr. Longridge's inspector it was clear that there was, at least, one cylinder in one single-acting engine, which, if it continued to wear at its present rate, would require re-boring, not in 42 years, but in about 2,500. When hundreds of engines of a particular type ran with very little wear for six or eight years, one might assume that they would not suddenly change their character in this respect. As to vibration, he had never advocated six-crank engines for lighting stations or for tramway work, except in the rare cases where absolute absence of vibration was necessary. For station work it was almost always sufficient to use the three-crank form, because the particular kind of vibration which still remained in such engines could be almost completely cured by heavy foundations. On board ship these were impossible, the subject was there far more urgent, and it was entirely from the marine point of view that it had been recently treated by Captain Sankey and himself before the Institution of Naval Architects. Much of Mr. Geipel's criticism turned upon the use of light loads, but for other reasons altogether engines ought not to be run lightly loaded. That also applied to what Mr. Shoolbred said about the absence of automatic expansion in most of the Willans engines, and governing by the throttle. If they worked at very light load, they certainly had to throttle the steam down lamentably low; but experiments showed that if they got down to very low load indeed, the throttled engine was absolutely more economical than the other, and that at even moderately light loads the difference between them was extremely small; it was something worth saving, but was very small. The moral of it all was that they should not work at light loads at all; but if they must do so, then as little as possible. Mr. Shoolbred opined that the larger the engines became, the better would be the chance for the double-acting engine. They had been inclined to think so themselves; but they had gone on to larger and larger engines, and results so far had been better as the engines grew larger. He thought it was simply a question of speed. If they could work the single-acting engine to double the speed, or more, of that at which they could definitely work the double acting, then there was no doubt about the advantage of the single-acting one. If they could not, they had to weigh the disadvantage of heavier parts against what advantages there might be in absence of knock and reduced wear. Mr. Dumas supposed steam packing had been tried before, but he (the speaker) thought not on the single-acting engine; that was to say, steam-packed rings were not worked by any means under the same conditions as in the single-acting engines. Mr. Dumas also asked if there were more wear at the top of the cylinders than at the bottom. He did not think so; it was quite equal at both ends. He also said it was evident the wear in valve rings must be somewhat excessive, and that those at the top of the trunk must be liable to collapse. They did not do so; that was the only answer he could give; they had been working for some time, and they did not start collapsing. A trunk from an engine which had been used for lighting the Savoy Hotel for four or five years had been brought there for their inspection, together with a cylinder and a set of piston rings. The wear in the cylinder was exceedingly small, and they could see the inside of the trunk was in beautiful condition. Mr. Dumas said the trunk must be in tension sometimes. He could assure them it would come to grief if it were—that is, if he referred to putting the line of parts generally into tension, but the trunk itself would be partially in tension on the up-stroke, when the inertia of the upper or steam pistons was being checked by the downward pressure on the lowest or guide piston only, but the stress was insignificant and he thought had no practical bearing on questions of fracture. The same speaker also spoke about the excessive pressure there must be on the crank-pins towards the top of the stroke at starting, when they had the pressure of the air buffer and of the steam acting together; but the air buffer was there for the very purpose of starting the parts; its pressure just balanced their inertia—

Mr. Dumas: I said on some part of the down stroke, not at the top. I quite agree that at the top of the stroke the pressure on the crank pin is not excessive, but after the inertia has been overcome to a great extent, then you have the air pressure combined with the steam pressure.

Mr. Robinson: The air pressure rapidly went off. It was intended to come into force only on the upper half of the stroke; by the time it reached the lower part there was very little left. The air cushion actually helped to keep the diagram square, and to give an even turning moment. Mr. Head spoke of a big Brotherhood engine, and of the seizing of its crank pin. Why he had not mentioned the Brotherhood engine was that he was afraid of making the paper inordinately long; therefore he only started with present practice, and did not refer to the Brotherhood engine, which had not been very largely used in central station work. Another reason was that it was not, strictly speaking, a constant thrust engine. It was so as regards the crank pin, but not as regards the shaft. The crank pin probably seized because it did not work in a bath of oil; whereas the crank pins in a vast number of single-acting engines, running at great speed, but in an oil bath, did not seize, but ran very well. With regard to the locomotives of the Chemin de Fer du Ouest, he was sure the President would be glad to know that they were now being made on the English plan. He was under one of those engines not long ago, and he could assure him that they were constructed with a full sense of propriety, with all the parts underneath. He had very inadequately dealt with the interesting criticisms offered on his paper, but he greatly lamented that they had not had the criticisms of some of the advocates of slow running engines. Mr. Morcom he was obliged to look on more as an ally than as an opponent, for he was a high speed man. He thanked them all very sincerely for the kind way in which they had received the paper.

AUSTRALIAN ELECTRICAL NEWS.

[FROM OUR OWN CORRESPONDENT.]

Few central stations can show better financial results than those obtained by the Strand Central Station in Sydney, started on June 1st, 1893. This station paid expenses during the first six months, and showed a profit at the end of the first year. True, the situation occupied by the plant, and the prices charged for supply, account very well for this. Situated right in the centre of a block of buildings bounded on three sides by the three principal Sydney thoroughfares, George, Pitt, and King Streets, and having for its fourth boundary a by no means unimportant street, Market Street, and comprising a number of important business establishments, shops, offices, warehouses, hotels, restaurants, and billiard saloons, it is without doubt the pick of Sydney.

The plant consists of two 100-volt Royce compound-wound dynamos, one of 60 units and one of 18 units, and one Brush arc light machine for 25 16-ampère lamps. These are driven by two Brush compound vertical engines of 50 I.H.P. and 130 I.H.P. respectively, steam being supplied at 140 lbs. pressure by two return tube boilers made by Morts Dock and Engineering Company, and each of 225 effective horse-power, Blake pumps being used for supplying feed water.

Business has increased so rapidly, that a new unit has recently been put down, consisting of a Willans engine coupled direct to a compound wound Crompton dynamo giving 440 ampères at 110 volts. For the first six months, working expenses were paid from revenue with a very small margin of profit, the load at the end of the six months being equal to about 1,300 incandescent lamps of 8-candle-power. Since then a good profit has been shown on each year's working, the load being now equivalent to about 3,400 8-candle-power lamps. The method of charging for supply is at the rate of 1s. per week per 16-candle-power lamp if used between the hours of 9 a.m. and 6 p.m., 1s. 6d. per week from 9 a.m. till midnight, and 1s. per week from 6 p.m. till midnight; 17s. per week for 16-ampère arcs from 6 p.m. till 12 midnight, and 10s. per week for small arcs. Thus it will be seen that the average earning capacity per 8-candle-power lamp is over 26s. per annum, and by a judicious arrangement of circuits for day load and night load, the earning capacity of the plant is increased. Curiously enough, though the load curve is one which would be welcomed joyfully by most central station managers owing to the large day load, yet it is actually in some ways a disadvantage for this station, owing, of course, to the method of deriving revenue. With a maximum load of about 520 ampères, the starting load at 9 a.m. is about 200 ampères, with a very steady and gradual rise to the maximum at about 5 o'clock. The actual rate of charging comes out at about 9d. per unit, the present output being at the rate of a little over 9,500 units per month; the actual works' cost being a little under 2d. per unit. The boiler furnaces are specially constructed to burn slack coal, which is delivered at 7s. 3d. per ton, and gives the surprising good result of 11·5 lbs. per unit delivered.

There are at present nearly 100 individual customers, ranging from an hotel taking two arc lamps and 200 16-candle-power incandescents, to the humble office taking only a single lamp. A brochure recently issued by Mr. A. H. Macarthur, proprietor and manager of the station, contains many testimonials, stating that not only do consumers find that there is a saving in annual cost as compared with gas, one writer putting the saving at 50 per cent. A particularly striking case is one in which incandescent gas burners have been satisfactorily replaced, both as regards efficiency and cost, by a similar number of 16-candle-power electric incandescent lamps.

The central station at Ballarat (Vic.), recently erected by the Crompton Electric Supply Company of Australia, is already showing good progress, about 400 incandescent lamps of 16-C.P. being taken up for private lighting, and 40 15-ampère arcs for street lighting and for the railway station and goods yards. The plant at present consists of two 400-light compound-wound Crompton dynamos, running at 110 volts, and one 40-light Crompton arc light dynamo. The machines are belt driven from countershafting, in turn driven by two single cylinder Tangye engines, each of 40 B.H.P. The boilers are of the return-tube type, of local manufacture. It is proposed to shortly double the capacity of the plant. The three-wire system is used for private lighting, overhead mains being at present installed, though in the principal streets an underground system is to be adopted at an early date. All cables were supplied by the Callender Company. Of the arc lights 30 are used by the railway department, the remainder being used for street lighting. The whole of the work has been carried out by Mr. Howard Harrison of the Crompton Company.

Though there was no official lighting at the Hobart Exhibition, the Brush Electrical Engineering Company obtained permission to put in a plant to supply the various exhibitors as required, and the 300-light Victoria machine had to be worked up to its full capacity to comply with the demands, which included two arcs for outside of the dome.

The Broken Hill Proprietary Gold Mine at Broken Hill, N.S.W., having already three Mordey alternators directly coupled to Brush engines, have decided to light their refineries at Port Pirie, and for that purpose have decided to instal a 25-unit plant of a similar description. Several of the new two-pole Brush dynamos have been recently installed in isolated plants in Sydney, and much interest has been evinced in the result of their working.

NEW PATENTS—1895.

9,919. "Heating body for electric soldering irons." F. W. SCHINDLER-JENNY and P. STOTZ. Dated May 20th. (*Complete.*)

9,937. "Improvements in the manufacture of active material for secondary batteries." S. HAMMACHER. Dated May 20th. (*Complete.*)

9,939. "Improvements in or relating to electric railways." A. L. ROBTON, jun. Dated May 20th.

9,961. "Improvements in connection with laying submarine electric cables." C. S. SNELL. Dated May 20th.

9,966. "Improvements in or relating to electric arc lamps." A. L. DAVIS. Dated May 20th.

9,967. "Improvements in electric regulators." H. N. MOODY. Dated May 20th.

9,969. "Improvements in dynamo-electric machinery." H. F. PARSHALL and THE BRITISH THOMSON-HOUSTON, LIMITED. Dated May 20th.

9,981. "The application of the motor-generator for purposes of electrolysis." A. E. OLD. Dated May 21st.

9,997. "Improvements in the application of electrical energy to the heating of air or other gaseous bodies." R. C. JACKSON. Dated May 21st.

10,017. "Improvements in telegraphic codes." M. L. DUFOUR. Dated May 21st.

10,027. "Improvements in telephonic installations for increasing the strength of the transmitted sounds." A. HAMM, G. BLANK, V. BRANDT, and G. KORMENDY. Dated May 21st.

10,029. "Improvements in pendants or electroliers for electric lamps." J. W. SINGER, W. H. SINGER, and E. R. SINGER. Dated May 21st.

10,052. "Improvements in electric railway signals." H. V. MILLER and A. C. MILLER. Dated May 21st. (*Complete.*)

10,058. "Improvements in or appertaining to electrically-illuminated advertisements, signs, and like devices." G. F. KENYON. Dated May 21st.

10,114. "The galvanopile, an improved form of galvanic battery." R. J. CROWLEY. Dated May 22nd.

10,134. "Improved means applicable for use in the decomposition of substances susceptible to electrolytic treatment." G. G. M. HARDINGHAM. (Communicated by R. Langbans, Germany.) Dated May 22nd.

10,142. "Improvements in electric gas-lighting devices." J. T. ARMSTRONG. Dated May 22nd.

10,154. "New or improved electrical attachment for drinking vessels." G. G. SMITH. Dated May 22nd.

10,155. "Improvements in or relating to telephone systems." M. FREUDENBERG. Dated May 22nd.

10,223. "Improvements in or relating to microphones." A. J. BOULT. (Communicated by L. Wallach, Germany.) Dated May 23rd.

10,241. "A novel construction and arrangement of appliances for generating electricity." A. LAUNCELOT, J. TAIT, and W. H. PEARSON Dated May 23rd.

10,249. "Improvements in and connected with multiple switch-boards for metallic circuit." H. OPPENHEIMER. (Communicated by Actien Gesellschaft Mix & Genest, Germany.) Dated May 24th.

10,250. "Improvements in or relating to electric bells, signals, and other means of electrical communication." T. SLOPER. Dated May 24th.

10,277. "Improvements in apparatus for measuring electrical currents." SIEMENS BROS. & CO., LIMITED, and E. F. H. H. LAUCKERT. Dated May 24th.

10,284. "Improvements in the manufacture of incandescent or glow lamps." C. J. P. ROBERTSON. Dated May 24th.

10,302. "Improvements in connection with laying submarine electric cables." C. S SNELL. Dated May 24th.

10,304. "A method of generating a current of electricity during the revolution of a carriage or car wheel." W. H. PEARSON and A. L. J. TAIT. Dated May 24th.

10,308. "An improved electric lock." L. DEFERT. Dated May 24th.

10,313. "Improvements in effecting telegraphic or telephonic communication through submerged cables, and in the construction of cables to be used for this purpose." W. S. SMITH and W. P. GRANVILLE. Dated May 24th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1894.

207. "Improvements in electrical transformers, and apparatus connected therewith." S. Z. DE FERRANTI. Dated January 4th. The inventor forms a magnetic circuit of the converter of a central core, ends and connecting bars. The central core is preferably circular and the coils are of large diameter and of flat section. He fixes either the primary or the secondary windings in one block on the centre of the core. The other coils either primary or secondary are suspended by vertical rods above and below the fixed coils and there is sufficient space left upon the core for these to be moved several inches up and down. 11 claims.

1,491. "Improvements in arc lamps." J. B. BARTON. (Communicated from abroad by W. Jandus, of America.) Dated January 23rd. Relates to improvements in arc lamps by which certain advantages are obtained. 8 claims.

1,903. "Improvements in or relating to electrodes for secondary batteries." M. WUILLOT. Dated January 29th. Consists in the electrodes being submitted to the secondary action of electrolysis of an alkaline bath instead of an acid bath. 5 claims.

2,274. "Improvements in the method of supplying electricity to electrically propelled tramcars and other vehicles, and in apparatus therefor." P. J. PRINGLE. Dated February 2nd. Relates to an improved method of, and apparatus for transmitting electrical energy from a central station or other supply to an electric motor carried by the vehicle to be propelled. 7 claims.

2,437. "Improvements in and relating to electric time-alarm and synchronising apparatus." A. A. C. E BASTOS. Dated February 3rd. Consists in adapting to any clockwork certain new arrangements of parts combined with the object of giving an alarm by means of electric bells established in predetermined places, where the attention of persons desirous of being called at any previously determined time may be attracted. 11 claims.

2,493. "Improvements in holders for electric incandescence lamps." R. F. RANDELL. Dated February 5th. Instead of securing the lamp to the holder by a bayonet joint or by hooks, the inventor secures the lamp to the holder by means of a pair of spring jaws which grip the usual collar or ring on the neck of the lamp, these jaws being attached to the holder in such a position relatively to the parts for making contact with the contact pieces on the lamp, that when the lamp is in the grip of the jaws the contact with these pieces is ensured. 4 claims.

2,730. "A new and improved protector for electric cables laid underground." T. B. GRANT. Dated February 8th. The inventor moulds in suitable lengths protectors of proper thickness with a cross-sectional shape of a semicircle with flanged extremities, or three sides of a square with flanged extremities. Bitumen, or a compound of tar and asphalte, is poured into the moulds, these being placed in position in the moulds, strips, or scraps of iron, or iron wire, or woven wire mesh or iron plate, or scraps of other metals. These strips or scraps or plates are placed in such a way that the compound completely surrounds them and binds them together, and they are arranged so that their position in the substance of the protector gives it great mechanical strength and rigidity, and the power to resist fracture from a blow of a pick or spade. 1 claim.

3,079. "An electric bell indicator." H. SANDERS. Dated February 13th. Relates to an electric bell indicator which will indicate six, or any quantity of numbers or names, by means of one movement or two movements. The movement consists of a metallic quadrant or rack which has as many teeth as it is made to indicate. 3 claims.

5,647. "Improvements in the manufacture of secondary coils for transformers." A. SCHNELLER and W. J. WISSE. Dated March 17th. Claims:—1. The manufacture of secondary transformer coils for use in the production of high tension electric currents, by boiling coils of insulated wire in wax or a waxy substance, then pressing them, and then putting them into preliminary use for the purposes of evaporating moisture therefrom, and of filling up the interstices therein, additional wax or waxy substance being supplied to the coils as long as heating thereof is produced by the passage of an electric current therethrough, as set forth. 2. A secondary coil for a transformer, composed of wire covered with several layers of insulating material, and the convolutions of which are embedded in wax, or a waxy substance, are separated from one another in a circular direction by strips or layers of insulating material, and are firmly secured together by binding cords passed several times transversely through the coil, which is finally provided with an outer protecting layer of material, such as shellac varnish, as set forth.

5,913. "Improvements in alternating current generators." J. S. RAWORTH. Dated March 21st. The inventor supports the conductor of which each coil or bobbin is composed, by tightly wound ligaments of suitable material, such as cord or metal wire, threaded through holes in the core and embracing the several turns of the conductor on each side of the coil bobbin. 2 claims.

6,089. "Improvements in the means of protecting electrical conductors." J. A. KINGDON. Dated March 24th. The inventor places over the insulated conductor a channel or trough of iron, steel or other metal, of a U-shaped section. The insulated conductor is laid in the round of the trough, and the opening of the trough may be closed by a strip or cover of wood, metal, or other material, so as to enclose the conductor. 5 claims.